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ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS.
See Advertisement page 69.
PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1704

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TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS
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Telephone: Holborn 2822. 1713

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For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGH BUCKETS & Parts, all sizes.
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Telephone: London Wall 3418. 1814

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THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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Regent Guillotine Shears and Power Presses
FOR SHEET AND PLATE WORKING.
THE REGENT SHEET METAL MACHINE TOOL CO., LTD.,
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 35.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } ROW'S PATENTS.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
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Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
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See Advertisement, page 27. 1878

Belliss High-Speed Enclosed
STEAM ENGINES FOR SALE:—
550 HP. Triple, 360 r.p.m., 160 lbs. w.p.
290 HP. Compound, new 1918 (V type valves), 100/120 lbs. w.p.
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One Superior 400 Kw. Howden - Siemens ELECTRIC GENERATING SET, 250 volts D.C., 350 r.p.m., 155 lbs. pressure.
One High-Class Horizontal Side - by - Side COMPOUND CORLISS ENGINE, 200 I.HP. at 80 r.p.m., belt flywheel 13 ft. diameter by 2 ft. 6½ in. on face, very suitable for export, for driving factory, sawmill, etc.
One Powerful Set COMPOUND HORIZONTAL HYDRAULIC PUMPING ENGINES, by Sir Wm. Arrol & Co., capacity 200 gallons per minute.
Two Steamdriven CENTRIFUGAL PUMPS, by Drysdale, capacity 1250 and 1390 gallons per minute.
In new condition and all seen here at Glasgow.
JOHN H. RIDDEL LTD.,
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Govan Engine Works,
LIMITED.
The whole of the
MACHINERY, TOOLS, PLANT, Etc.,
of
GOVAN ENGINE WORKS.
(lately belonging to
Messrs. DUNSMUIR & JACKSON, Limited,)
FOR SALE
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For particulars apply
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Glasgow.
D 431

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John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers,
&c., &c. 1582

Penningtons, University
TUTORS, 354, Oxford Road, Manchester. Estab. 1876. Rural now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

Technical Translations from or into Spanish, Italian, French, German, Russian, &c., by experts.—VICTORIA TRANSLATION BUREAU, 21a, Southampton Bldgs., Chancery Lane, W.C. 2

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YARROW BOILERS.
1553

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GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 62, May 16. 2402

Iron Castings up to
1 ton weight. Enquiries invited.
COCHRAN & CO., Annan, LTD.,
Annan, Scotland. 2106

HEAT INSULATION.
CELITE PRODUCTS CORPORATION,
Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, May 9.

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 1826

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 2005

Plenty and Son,
LIMITED,
STATIONARY, STEAM AND MARINE ENGINEERS.
NEWBURY, ENGLAND. 1831

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54 & 55, FETTER LANE, LONDON, E.C.4.
62 & 63, LIONEL STREET, BIRMINGHAM,
and Principal Provincial Cities and Abroad.

Diesel Engines, 300, 530, 800,
1200 and 1750 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. For all spares above sizes in stock.
HICK DIESEL OIL ENGINES, LTD.,
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Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 26 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 73, May 9.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

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Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 5/11, Trafford Chambers, 58, South John Street, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2108

T. G. Howes Thomas, (Inst.

C.E. Coach, late of Westminster). Consulting Engineer, has resumed his "Up-to-date" Coaching by correspondence, and is prepared to advise on proposed or accepted patents.
34, Baldwin Street, Bristol. D 847

TENDERS.

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

1. BUFFERS.
2. MISCELLANEOUS ARTICLES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Buffers," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 13th June, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the Specification.

Copies of the drawings may be obtained at the Offices of Messrs. Robert White & Partners, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
20th May, 1924. D 849

FELIXSTOWE URBAN DISTRICT COUNCIL.

The Urban District Council of Felixstowe invite

Tenders for the Manufacture,

SUPPLY, DELIVERY and ERECTION on site of :—

(a) CABLES.
(b) TRANSFORMERS.
(c) CONVERTER SETS.
(d) SWITCH GEAR.

Specifications and Forms of Tender may be obtained on application to the Consulting Engineer, Mr. R. P. Wilson, Aldwych House (7th Floor), Aldwych, W.C.2, on payment of a Deposit of £2 for each section.

The model general conditions issued by the Association of Consulting Engineers will apply to the contract.

Tenders must be on the form provided and must be delivered to the Clerk of the Council, addressed to the Town Hall, Felixstowe, not later than Twelve noon, on Saturday, June 21st.

The Council do not bind themselves to accept the lowest or any Tender.

Deposits will only be returned upon receipt of a *bona fide* Tender accompanied by the Specifications and Drawings.

(Signed) MONTAGUE HUMPHREY,
Town Hall, Town Clerk.
Felixstowe. D 842

SALFORD UNION.

UNION INFIRMARY, PENDLETON, NEAR MANCHESTER.

RE-ADVERTISED DUE TO DEATH OF CONTRACTOR'S PRINCIPAL.

The Salford Board of Guardians invite

Tenders for Heating and Hot

WATER SERVICE APPARATUS, including Calorifiers, Pumps, Mains, Radiators, and the like, for above Infirmary and Nurses' Homes Extension.

Drawings of the Plant may be inspected at the Offices of the Engineer, Mr. T. Roland Wollaston, M.I.M.E., Lord's Chambers, 26, Corporation Street, Manchester, on or after May 19th, between the hours of Ten a.m. and Four p.m.

Specification, Schedule of Quantities, Form of Tender and Conditions of Contract may be obtained from the undersigned, on receipt of written application, enclosing cheque value Two Guineas, which sum will be refunded on due receipt of *bona-fide* Tender.

The Board do not bind themselves to accept the lowest or any Tender.

The selected Contractor will be required to subscribe to the Conditions as regards employment of labour, etc., as set forth in the Board's regulations.

Sealed Tenders, endorsed "Engineering Section2," must be delivered at my Offices, not later than Ten a.m. on Saturday, June 14th, 1924.

By Order.
H. H. INCHLEY,
Clerk to the Guardians.

Poor Law Offices,
Bocles New Road,
Salford.
13th May, 1924. D 757

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C. 2, invite

Tenders for:—

1. STATIONERY, &c. ... ... Fee 10/-
2. LAMP GLASSES, &c.... ... ... " 7/6
3. PAINTS, &c. ... ... " 7/6
4. ELECTRIC OVERHEAD TRAVELLING CRANES. ... ... " 10/-

Tenders are due by Eleven a.m. on 3rd June, 1924. Tender forms obtainable at above address. Fees not returnable. D 851

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, INVITES TENDERS for :—

1. COMPOUND SURFACE CONDENSING ENGINES and BOILERS for Single Screw Launches.
2. MILD STEEL PLATES and SHEETS.
3. OPEN LINK and SHORT LINK CHAIN, and CHAIN CABLE.

Tenders due on the 12th June, 1924, for No. 1, and on the 13th June, 1924, for Nos. 2 and 3.
Tender forms obtainable from above. D 843

FOR SALE, BUSINESS of the WALKER-HANNA BEARINGS, LIMITED (now in Liquidation) of Great Jackson Street, West Gorton, MANCHESTER.

Tenders are Invited for the

whole ASSETS of the above Company including MACHINERY, PLANT, STOCK, etc., amounting as per valuation dated 8th May, 1924, to £1450.

The Buildings are Leasehold and have been partly erected by tenants. The rent is £70 per annum.

Copies of Inventories may be seen either at the Liquidator's Office or at the Works, Great Jackson Street, West Gorton, Manchester.

The highest or any offer may not be accepted.

Tenders must be lodged with the Liquidator not later than 4th June, 1924.

Further information may be obtained from the Liquidator, HAROLD J. MACLEISH, C.A., 116, Hope Street, Glasgow. D 809

CITY AND COUNTY BOROUGH OF BELFAST.

TO BOILER MAKERS.

The Baths and Lodging House Committee invite

Tenders for the Supply and

INSTALLATION of TWO LANCASHIRE BOILERS at the Municipal Baths, Peter's Hill, Belfast.

The Boilers to be in accordance with specification and conditions, which may be obtained from Mr. J. W. Gilliland, Architect, 43, Waring Street, Belfast, on payment of the sum of One Guinea, which will be refunded on receipt of a *bona fide* Tender.

Parties tendering must comply with the Council's Standing Order relating to wages, hours of labour, etc.

Tenders, endorsed "Tender for Boilers, Public Baths," to be lodged in the office of the undersigned not later than Tuesday, 3rd June, 1924.

An official receipt must be obtained for every Tender delivered by hand. Tenders sent by post must be registered.

The lowest or any Tender will not necessarily be accepted. D 795

R. MEYER, Town Clerk.

METROPOLITAN WATER BOARD.

TENDER FOR THE SUPPLY OF 60 in. STEEL PIPES AND SPECIALS.

WALTON PUMPING STATION EXTENSION.

The Metropolitan Water Board invite

Tenders for the Supply and

DELIVERY of 13 STEEL PIPES and SPECIALS required for the 60 in. Suction Main at their Walton Pumping Station.

Forms of Tender, Specifications, Bills of Quantities, together with drawings, may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1, by personal application (Room 155) or upon forwarding a stamped addressed brief envelope.

Tenders must be on the official forms, enclosed in sealed envelopes and addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1," endorsed "Tender for Steel Pipes, Walton," and delivered at the Offices of the Board not later than Eleven a.m. on Tuesday, 10th June, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C. 1.
17th May, 1924. D 838

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to :—
AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 34/45—
66,000 VOLT INSULATORS.

CHARGE :—£2 2s. for the first three copies of Tender Form, Conditions of Contract, and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10/6 each. This charge is not returnable.

PRELIMINARY DEPOSIT :—A Preliminary Deposit of £50 is to be lodged with Tender.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 4th August, 1924.

H. LIDDELOW,
Secretary. D 833

APPOINTMENTS OPEN.

STAFFORDSHIRE EDUCATION COMMITTEE. COUNTY TECHNICAL COLLEGE, WEDNESBURY.

An Assistant Lecturer is

REQUIRED to begin work in September. Salary will be paid according to the Burnham (Technical) Scale, less the 5 per cent. abatement for the current financial year. Candidates must be qualified to give class-room and laboratory instruction in Physics and Mathematics. Works and Drawing Office experience in Electrical Engineering is desirable. Further particulars and forms of application, which must be returned not later than May 31st, 1924, may be obtained from the undersigned on receipt of a stamped addressed envelope.

GRAHAM BALFOUR, Director of Education.
County Education Offices, Stafford, 3rd May, 1924. D 685

DARLINGTON EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

Wanted, Head of Mechanical

ENGINEERING DEPARTMENT, to commence 1st September, 1924. Graduate of a British University, with Works and Teaching experience. Burnham Technical Scale (less 5%). Stamped addressed envelope for Application Forms and further particulars. Completed Forms must be returned by 28th May, 1924, to the CHIEF EDUCATION OFFICER, Darlington. D 796

LEIGH MUNICIPAL TECHNICAL SCHOOL.

A Teacher of Mechanical

Engineering is REQUIRED, to take charge of the Mechanical Engineering Laboratories. Applicants should possess recognised academic qualifications, and should have both works and teaching experience. Salary at Burnham Technical Scale, less authorised deductions. Allowance will be made for recognised industrial experience in fixing the commencing salary, as provided by the above Scale.

Forms of Application with particulars of the post will be sent on receipt of a stamped addressed foolscap envelope. Applications should be sent in not later than Saturday, 6th June, 1924.

JAMES WARD,
Director of Education,
Town Hall, LEIGH (Lancs).
19th May, 1924. D 823

TECHNICAL COLLEGE, BRADFORD.

Applications are Invited for

APPOINTMENT as HEAD OF THE BUILDING and CIVIL ENGINEERING DEPARTMENT in the College.

Commencing salary (in accordance with Burnham Scale) £600 per annum.

Full particulars of the appointment and forms of application may be obtained from the Principal of the College. Applications should be sent to me not later than 9th June.

N. L. FLEMING,
Town Clerk.
20th May, 1924. D 821

Works Manager Required

for important Weldless Steel Tube Works, competent to take full control; good experience essential and must be a thoroughly capable organizer; excellent opening for the right man. Applications, which will be treated in strict confidence, must state full particulars, including experience, age, and salary required.—Address, D 822, Offices of ENGINEERING.

General Manager Required

for a large Structural and Gas Engineering Works in the Midlands (Birmingham District) employing about 700 hands. Applicants must have had a thorough theoretical and practical engineering training in the design and construction of Gasholders, Purifiers, Gas Plant and Structural Steelwork; must be fully qualified to work out calculations of Stresses and Strains, and to take general administrative management.—Apply, by letter (which will be treated confidentially), stating age, experience and salary expected, to Z.H.R., care of Deacon's, 7, Leadenhall St., London. D772

General Manager Re-

QUIRED by Electrical Supply Company in Spain. A Gentleman, thoroughly experienced in the economical organisation and control of modern electric generating and supply installations. A knowledge of the Spanish language is desirable. Applications, giving full particulars of experience, names of referees and salary expected should be forwarded by the 31st inst.—Address, D 810, Offices of ENGINEERING.

SOUTH INDIAN RAILWAY.

A Works Manager is Required

for the Locomotive and Carriage and Wagon Workshops of this Railway at Trichinopoly, now in course of erection.

The salary of the appointment will be according to the qualifications of the candidate.

The agreement will in the first place be for three years and salary will commence on the date of embarkation for India. The passage to India will be paid by the Company.

Candidates, who should be between the ages of 30 and 40, should have had a first-class education, with subsequent training and experience in Railway or Manufacturing workshops, have held administrative positions in engineering workshops, and be well versed in modern methods of workshop procedure and organisation.

Forms upon which applications must be made may be obtained on written request to Messrs. Robert White & Partners, 3, Victoria Street, London, S.W.1, the Consulting Engineers to the Company.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
17th May, 1924. D 815

Metallurgist Wanted for

London position. Knowledge of non-ferrous metals, particularly light alloys. Metallurgical works experience desirable, also knowledge of materials for petrol engines. Salary £360 to £480 according to experience and qualifications.—Address, D 776, Offices of ENGINEERING.

The Royal Air Force

REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, POWER STATION TRADESMEN and WIRELESS OPERATORS. Age limits 19 to 30. Pay from 24/6d. to 38/6d per week, on enlistment, and all found. Allowance for wife and children to men 26 and over. —Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. D 385

Sales Engineer, Bombay.

Previous commercial experience and full technical qualifications essential, suitable remuneration to the right man. Applications only considered from gentlemen stating age, salary required, and complete details of technical education and commercial experience,—Address, D 839, Offices of ENGINEERING.

Engineer to Take Entire

Charge of Drawing Office. Must be specialist in Aerial Ropeways. State full particulars, experience, salary, etc.—Address, D 747, Offices of ENGINEERING.

India.—Engineer-Salesman

WANTED for English firm in Bombay. Must have thorough knowledge of Steam Power Plants and Mill gearing. General technical knowledge and drawing office experience essential. Single man under 30 preferred. Permanent post with good prospects for the right man. Salary according to qualification.—Address, stating briefly training and experience, D 738, Offices of ENGINEERING.

NEW ZEALAND.

Applications are Invited

for an ASSISTANT CHIEF MECHANICAL ENGINEER to the New Zealand Government Railways. Commencing salary £850 per annum, rising to £1000. Age limit 40.

Applicants are required to have had practical experience of the control of the Locomotive Running Branch of a Railway operated by Steam, and to have held a responsible position on a Railway equipped for Electric Traction.

Further particulars and forms of application obtainable from the HIGH COMMISSIONER FOR NEW ZEALAND, 415, Strand, London, W.C.2, by whom completed applications will be received up to and including 21st June, 1924. D 800

Engineers Required by

the GOVERNMENT of BRITISH GUIANA for two years' service. Free passages.

M/12760 (Engineer) Candidates, not over 45 years of age, must be fully qualified Civil Engineers who have had extensive experience in charge of water and well boring operations. Salary £1000.

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250 Kw. GENERATING SET, Triple Expansion Engine, by Bellias & Morcom, coupled to R.C.C. Generator, 460/550 volts, 380 revs.

160 Kw. 3-Phase GENERATING SET, Compound Engine direct coupled to 3-Phase Alternator, 550 volts, 174 amps, 40 cycles, 300 revs.

74 Kw. GENERATING SET, by W. H. Allen, Sons and Co., Ltd., Compound Engine, direct coupled to Generator, 105 volts, 705 amps, 475 revs.

STONE BREAKERS, new and second-hand, of all capacities, and sizes, by leading makers, from 12 in. by 7 in. to 36 in. by 9 in.

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Surplus Machines.

Two large warehouses at Coventry containing a splendid variety of new and second-hand machines at specially reduced prices. The following is a selection—Inspection invited.

AUTOMATIC MACHINES.

Cleveland ⅜ in., ½ in., ⅝-1½ in. and 2-2½ in. Model "A" Automatics in splendid condition.

1 in. by 5 in. New Britain Six Spindle Automatic (New).

No. 6 Alfred Herbert Auto-Lathes, 19 in. swing, 10 in. stroke of capstan.

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40 in. Webster & Bennett Duplex Boring Mill, (slightly used).

24 in. Bullard "New Era" Vertical Boring Mills (New).

60 in. Gisholt Vertical Boring Mill, two swivel heads, power traverse (Practically new).

GEAR CUTTING MACHINES.

No. 6 Fellows Gear Shapers, for spur gears, 35 in. by 6 in., 4 D.P.

No. 2 Reinecker Bevel Gear Cutter (Bilgram type), max. pitch, 3 D.P.

No. 2 Barber Colman Gear Hobbing Machine (Used).

GRINDING MACHINES.

6 in. by 32 in. Norton Plain Cylindrical Grinders (Used).

10 in. by 17 in. Cincinnati Universal Tool and Cutter Grinder with belt drive.

No. 3 12 in. by 42 in. Landis Universal Grinder, with countershaft, fully equipped.

LATHES (New and Second-hand).

A large selection of splendid straight and gap bed lathes, all in first-class working condition, including—

3½ in. by 3 ft. 6 in. Miller Bench Type Lathe, C.P.B.G. (New).

6½ in. by 6 ft. 0 in. Dean, Smith & Grace S.S. and Sc. Lathes with solid spindle.

6½ in. by 6 ft. 0 in. Lang Gap Bed S.S. & Sc. Lathes, C.P. B.G.

PLANING MACHINES (Second-hand).

22 in. by 22 in. by 5 ft. 0 in. American Tool Works Planer, with one head on cross rail.

30 in. by 30 in. by 8 ft. 0 in. Redman Planer, two heads, V.S. c'shaft.

60 in. by 60 in. by 16 ft. 0 in. Stirk H.S. Planer, two heads, and one on near upright, Vickers' drive (without Motor).

SURPLUS LIST No. "10" GIVES ADDITIONAL DETAILS AND PRICES. D 837

For Sale, &c., continued on page 105.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN extra general meeting of the Institution of Mechanical Engineers was held on Friday last, the 16th inst., at Storey's Gate, Westminster, Mr. W. H. Patchell, the President, occupying the chair.

THE THIRD REPORT OF THE STEAM NOZZLES RESEARCH COMMITTEE.

The subject for consideration was the "Third Report of the Steam Nozzles Research Committee." Before this was read Captain H. Riall Sankey, Chairman of the Committee, gave a short account of the inception of the research, and explained the delay due to the war.

In presenting a *resumé* of the salient features of the report, Professor Storey remarked that the programme laid down by the committee in the First Report was designed to test, firstly, 1-in. Parsons standard blading and, secondly, 12 deg.–20 deg. impulse converging nozzles, both with thick and thin partition plates; while the Second Report covered the 1-in. Parsons nozzles and the 20 deg. impulse nozzles with thin plates, together with the efflux angles of the steam at exit into the atmosphere. In the present report the work was carried a stage further in that tests with 20 deg. impulse nozzles with thick partition plates had been completed. These were less efficient than those with thin plates. In concluding he wished particularly to thank Mr. Petrie, without whose unremitting efforts as Research Superintendent the Committee could not have carried on the investigation.

Mr. Frederick Samuelson, of the British Thomson-Houston Company, Limited, opened the discussion. He said that during a recent visit to America he had become acquainted with results obtained there during the past four years with a reaction tester. The results agreed generally with those of the Committee, but the velocity coefficients were about 2 per cent. higher all round. This might be due, in part, to the testing instrument itself, or it might be due to a better inlet arrangement of the nozzle. He had every confidence in the reliability of the nozzle tests at Manchester, and the reason for the difference of 1 per cent. to 2 per cent. to which he had referred would some day be explained; he was inclined to think that the shape of the nozzles was responsible for the difference, not the apparatus. He believed also that nozzle efficiencies in a good turbine were really higher than the Manchester curves indicated. Recently his firm had made a test of a 15,000-kw. turbine, recording an efficiency of 80 per cent. at overload and 79 per cent. at full load.

Assuming that 79 per cent. was the correct figure, and allowing for generator efficiency, losses in bearings, pumps and so on, the overall efficiency of the turbine was 82¾ per cent., corresponding to an average stage efficiency of 80 per cent. Assuming the blading was of equal efficiency with the nozzles—which was putting it high—the velocity coefficient averaged 94½ per cent., and considerably more in the part traversed by wet steam. The turbine had one velocity wheel with two rows of blading.

The steam velocities in the machine he was discussing ranged from 740 ft. to 1,300 ft. per second, so that they were lying on what might be termed a "bad curve." The results showed, however, that nozzle efficiences must be considerably higher than had been obtained at Manchester.

Professor A. L. Mellanby spoke next, saying that he would confine his remarks to the test of the elementary straight nozzle. In the experiments he had made in conjunction with Dr. Kerr, they had estimated the losses at different points from inlet to discharge. The method adopted was based on that originated by Stodola. In frictionless flow we had the equation

$$0{\cdot}718\left(\frac{V_1}{P_1}\right)^{\frac{1}{n}}\frac{G}{A}=\frac{r\left(1-r^{\frac{n-1}{n}}\right)}{r^{\frac{n-1}{n}}}$$

Where V_1 represented initial volume, P_1 pressure, G the quantity of the steam passing, and r the pressure ratio at any point. Nozzles not being perfect, the theoretical flow was greater than the actual amount. To provide for this we could, as they had shown in various papers, write the equation in the form

$$0{\cdot}718\left(\frac{V_1}{P_1}\right)^{\frac{1}{n}}\frac{G}{A}=\frac{r\left(1-k-r^{\frac{n-1}{n}}\right)}{k+r^{\frac{n-1}{n}}}$$

where the coefficient k was a measure of the losses and could be calculated from the test observations at different points along the nozzle. The search tube method had been criticised, but the speaker claimed that it was a great deal more delicate as a means of recording pressure drop than was often imagined.

Mr. B. Pochobradsky, of Messrs. Fraser and Chalmers Engineering Company, remarked that the results presented in the present report appeared to confirm those obtained in the case of the previous one. The results in the report went further, however. The elementary nozzles tested showed that, disregarding very low velocities, there was little difference in loss whether the velocity was low, medium or high. He thought this might be extended to ordinary nozzles. With these, losses were higher than with the elementary nozzle. This he suggested was due to the curved path the steam had to follow in an ordinary nozzle, in which the steam was compressed on the concave side and the velocity on the convex side was higher than that on the concave side, with a resulting disturbance. This increased the losses for two reasons: (1) the velocity across a channel was not uniform, and (2) on the concave side there was compression and the steam had to be re-expanded. In this cycle losses arose. It seemed, therefore, to the speaker that the radius of steam flow was of great importance. this, he thought, was to some extent confirmed by the two tests on the two Parsons' nozzles, where the smaller blades gave a substantially reduced efficiency, which he attributed to the sharper curvature. He asked that full details of the Parsons' blades should be published. The difference between the American and the Manchester results, mentioned by Mr. Samuelson, were probably correctly attributable to the inlet conditions. He did not doubt the accuracy of the apparatus used for the tests, but he wondered whether there would be a difference if the cage were made entirely independent of the plate and made stationary, so that any influence which the escaping steam might have would not react on the accuracy of the apparatus.

One suggestion he would like to put before the Committee, namely, to test another type of impulse nozzle, largely used at the present time, machined all over, with very sharp inlet edge, sharp outlet edge and gradually thickening profile, with a maximum somewhere about one-third from the inlet. That was the modern impulse type of nozzle.

Mr. I. V. Robinson said that the Beama were manufacturers, and as such, they were thoroughly satisfied with the excellence of the work carried out. The one important point brought out by the experiments was the increased efficiency at velocities below 600 ft., giving the peak at about 400-ft. Of that the manufacturers had already availed themselves. Many turbines were now being built of the multi-stage impulse type, in which the initial stages were designed for low-speed velocities and corresponding low blade velocity. In reference to Mr. Samuelson's observations, the speaker said that Professor Callendar was carrying out, for manufacturers, inter-stage efficiency tests on some half dozen big machines. The publication of the results, however, depended upon the manufacturers individually. The figures mentioned by Mr. Samuelson were very interesting.

Mr. F. H. Livens, inquired as to the correctness of the manner of dimensioning the centres of the holes, in the case of Fig. 12 in the Report. He wished to know whether the 2¾-in. just below the section was really the distance from the centre of one hole to the inner edge of the opposite hole, or if it was the pitch circle. Professor Stoney replied that it was really the pitch circle.

Mr. P. Telford Petrie said that it had been pointed out in the discussion on the Second Report that superheat seemed to have some effect on the losses. Mr. Shakeshaft and he had, however, been unable to satisfy themselves that this was really the case, but the experiments since made on the straight nozzles left no doubt of the fact.

Curves worked out by one of his research students showed discharge coefficients, and it was apparent from these that the higher superheats had the higher discharge coefficients, with lower efficiency. This seemed a paradox.

Professor Stoney then replied to the discussion. He said that it was quite possible that the results of the Manchester tests might be lower than those obtainable in actual turbines. That also might be the case with the Parsons' blading as well as with the impulse. It would be of interest if Mr. Samuelson could give the dimensions of the nozzles tested in the United States, because, as had been pointed out, there was undoubtedly a difference of efficiency between large and small nozzles, while the shape was very important. Knowing the nozzle dimensions in the case of the American tests, it might be possible to make a similar set and test them under similar conditions at Manchester. Mr. Pochobradsky had also noted the likelihood of a difference of result if the nozzles were not absolutely of the same shape, and probably there were small differences in shape between the Parsons ¾ in. and 1 in. The speaker would endeavour to get sections and enlargements made, so that on the drawing they would be the same size; in this way it would be possible to see whether the two sets of blading were relatively of the same shape or whether there was any essential difference. Mr. Pochobradsky had referred to a modern type of nozzle machined out entirely. This was really equivalent to a thin Parsons blade, or very similar thereto. If Mr. Pochobradsky would make a nozzle box with machined nozzles, giving similar openings, &c., to those in use at Manchester, they could be tested in the nozzle tester.

On the subject of the cage being independent of the plate he feared that the results would be very unreliable, especially if there were any rebound of the steam. With the arrangement actually adopted such a rebound would involve no error.

The speaker had been much interested in the agreement between Prof. Mellanby's Glasgow experiments and those of the Committee. He wondered if Professor Mellanby had detected the effect of superheat on k, and whether the Professor would be able, by his theory, to account for the difference in efficiency between one superheater and another. Mr. Martin had pointed out that the viscosity of highly superheated steam was more than that of moderately superheated steam, and that therefore, the efficiency of the nozzle would be less. He might, in conclusion, say that he was now proceeding to test the 12 degrees angle nozzles, and it was hoped that another report would be ready in another twelve months, which would probably embrace the results of tests on Mr. Pochobradsky's suggested nozzle.

Professor Mellanby expressed surprise at Prof. Stoney's question on the subject of superheat, as the speaker had pointed out the effect of superheat in reducing efficiency in his paper read before the North East Coast Institution of Engineers and Shipbuilders in 1920. In a paper he had read before the Institution of Mechanical Engineers on the Super-saturated condition the actual diminution of efficiency with superheat was given in the form of a diagram.

The President then closed the proceedings with the announcement that the Summer meeting would take place on the 7th to the 9th July and further particulars would be available in the *Journal* about the middle of June. On July 5, in the morning, there would be a further discussion on the subject of hydraulic power plant. One discussion had already been held at the Institution on Professor Gibson's paper, constituting a report of the Committee. The Institution of Civil Engineers were anxious to get that report discussed a little further, and as they could not have the meeting in their own building the discussion would take place in the building of the Institution of Mechanical Engineers.

THE INSTITUTION OF CIVIL ENGINEERS.—By the invitation of Mr. Fred J. Dixon, M.Inst.C.E., Engineer-in-Chief to the South Staffordshire Waterworks, a visit to various works belonging to this company has been arranged to take place to-morrow, the 24th inst.

VARIABLE SPEED 3-PHASE MOTORS AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

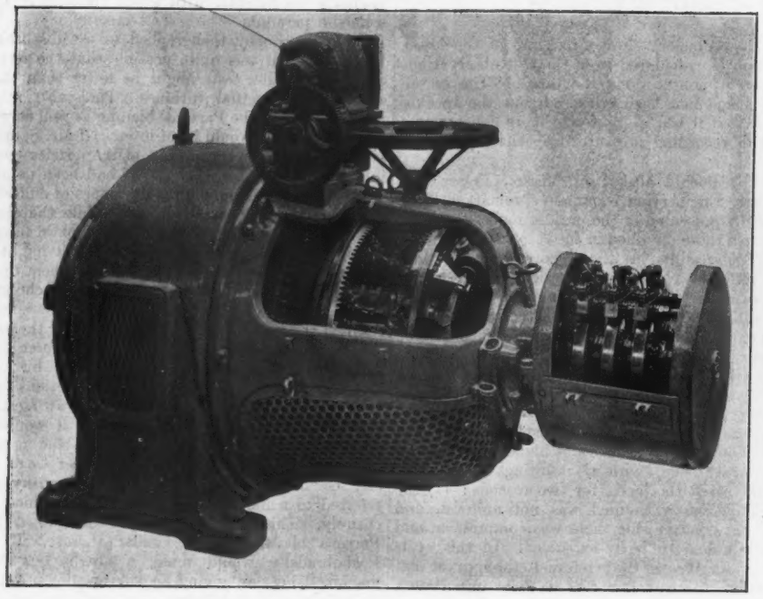


FIG. 1.

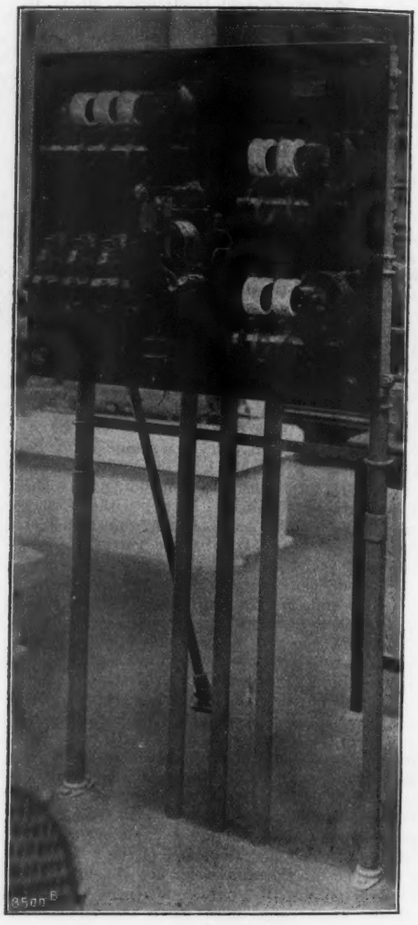


FIG. 2.

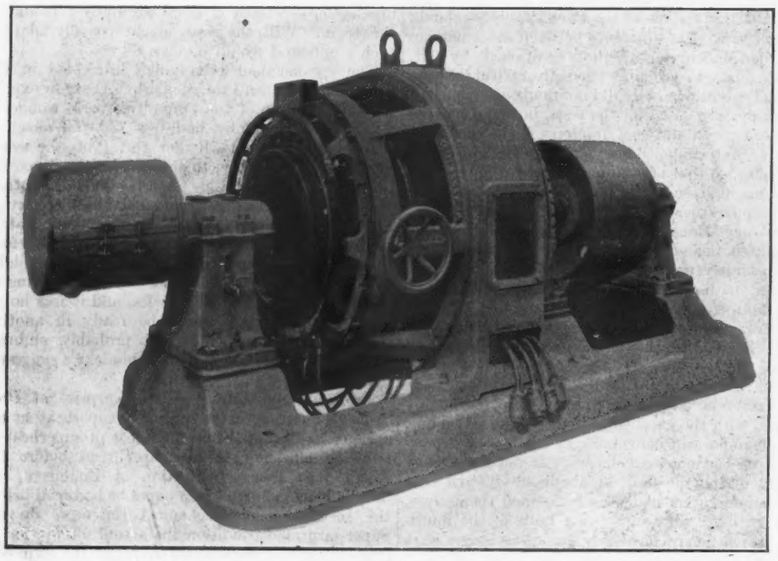


FIG. 3.

VARIABLE SPEED 3-PHASE MOTORS.

BEFORE full advantage could be taken of the economic possibilities of the polyphase alternating-current system, as compared with the direct-current system, for generation, transmission and distribution of electrical energy, it was necessary that motors should be available to meet the varied motive power requirements of modern industry. In many instances, where a constant or practically constant speed drive is required, the simple, robust and efficient induction motor meets the case admirably, while in particular instances, where one or two definite speeds are necessary induction motors with double windings giving different numbers of poles are sometimes provided. Other methods are to arrange the windings for connection in different groups, so that different numbers of poles are obtained, or to use two or more induction motors in cascade connection.

In order to obtain a speed which can be varied over a wide range, alternating-current commutator motors with adjustable tappings or moveable brushes have been used. Motors provided with adjustable tappings, however, give only a limited number of speeds, and those with moveable brushes usually have a speed-torque characteristic similar to that of the direct-current series motor, *i.e.*, the speed decreases as the torque increases. For many applications, such motors are unsuitable, and often it has been necessary to convert an alternating-current supply to direct current so that direct current, shunt or compound wound motors, with adjustable speed characteristics could be used.

To avoid this conversion, and at the same time to obtain a motor the speed of which is infinitely variable at will from zero to a maximum under any load conditions, the British Thomson-Houston Co. Limited, of Rugby, have developed and patented a machine, the speed of which also remains practically constant under changing load. The first was set to work in 1916, and together with many others since built has proved its value and reliability in actual operation. To-day, motors of this type, aggregating approximately 4,500 h.p., are operating satisfactorily. The speed of this type of motor is under perfect control throughout the normal speed range, usually 3 to 1, the commutator and brushes acting as a controller with an infinite number of steps. It is also a simple matter to obtain very low speeds for "inching" purposes. These features have made the motor very successful in such applications as paper-making, reeling, cutting, calendering and drying, also in paper and calico printing, as well as in the production of textile materials. The motor is also very suitable for machine tool drives, as in addition to the easy and efficient speed control over the whole speed range, there is a very small increase in speed when the load is taken off. Another application for which the motor has been successful is that of driving hydraulic pumping equipments, where the rise and fall of the accumulator lowers and raises automatically the speed of the motor, thus maintaining maximum storage capacity without frequent and objectionable starting and stopping. Other applications for which the motor which is known by the makers as their type C.H., is well adapted include

VARIABLE SPEED 3-PHASE MOTORS AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

Fig. 4.

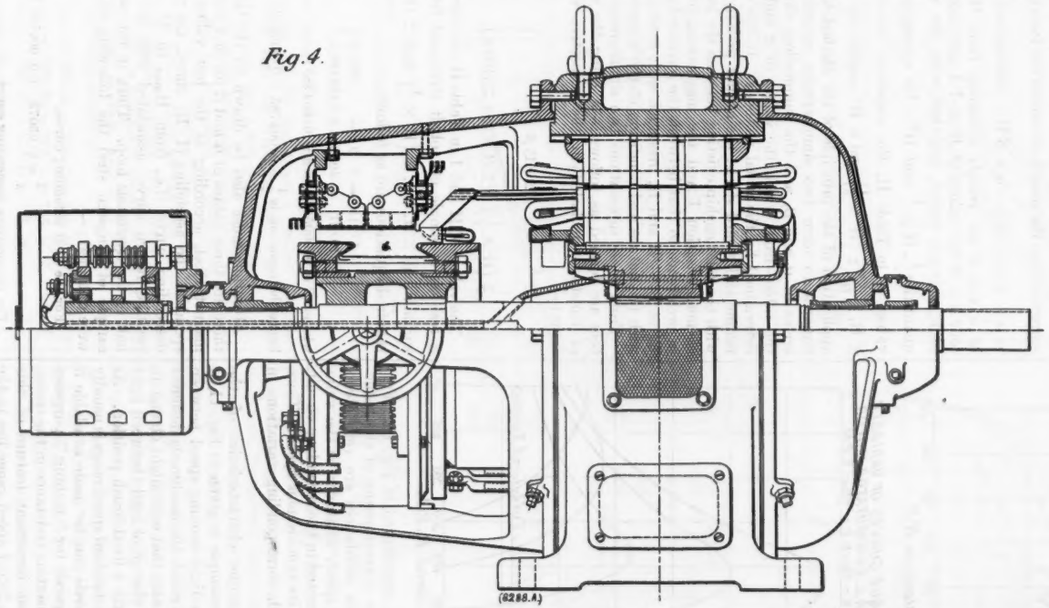


Fig. 5.

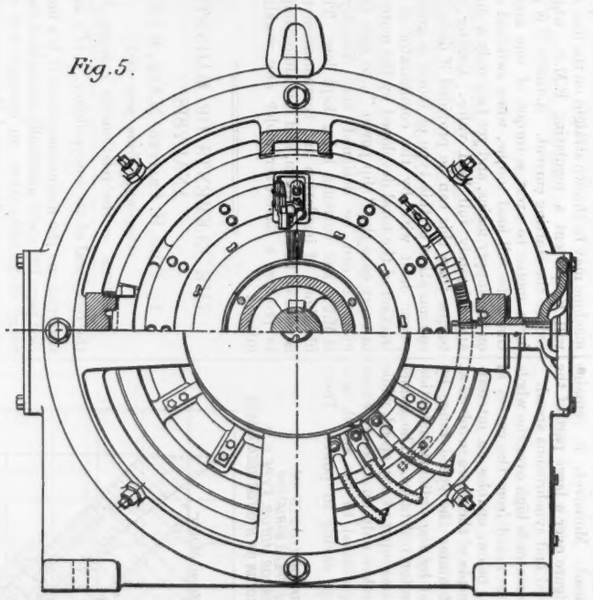


Fig. 6.

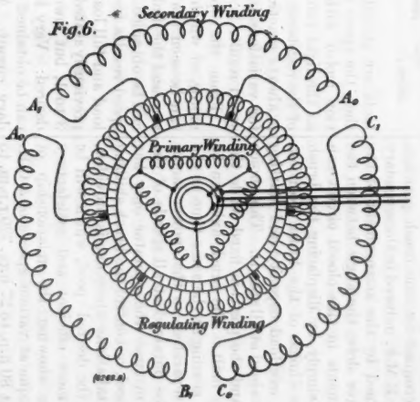


Fig. 7.

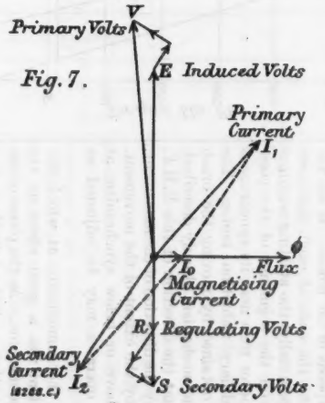


Fig. 8. POWER FACTOR CURVES OF VARIABLE SPEED A.C. COMMUTATOR MOTOR.

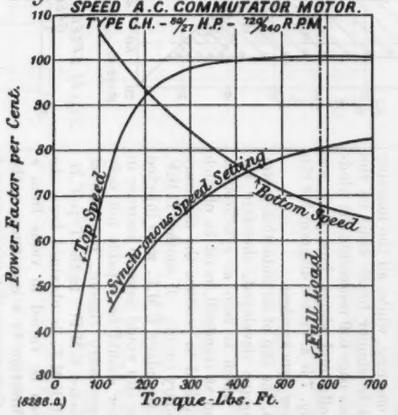
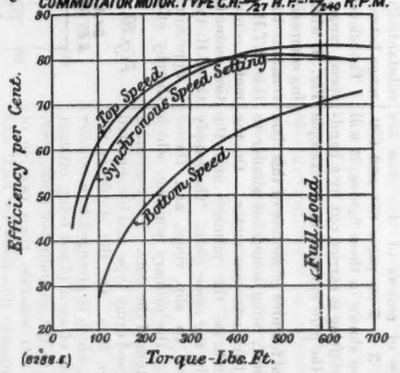


Fig. 9. EFFICIENCY CURVES OF VARIABLE SPEED A.C. COMMUTATOR MOTOR. TYPE C.H.-68/27 H.P.-725/240 R.P.M.



exhausters, chain-grate stokers, rubber manufacturing machinery, and, in fact, any duty where efficient speed variation is required.

A motor of this class is shown by the British Thomson-Houston Company on their stand in the Palace of Engineering, at the British Empire Exhibition. The motor, which is illustrated in Fig. 1, on the opposite page, is a 400-440-volt, 3-phase, 50-cycle machine which has a speed range varying from 1,350 r.p.m. to 350 r.p.m. The output between these speeds varies from 25 h.p. to 8 h.p. In order to obtain a constant torque at any speed between these limits, the motor at the Exhibition is direct-coupled to a differential compound-wound generator with separately excited shunt so as to simulate the conditions of constant resisting torque usually met with in commercial applications. The speed of the three-phase motor is varied by altering the position of the brushes, the principle of the method being described below. As will be gathered from Fig. 1, the brushes are actually shifted by a small motor mounted on top of the frame of the main motor. Control is effected from the panel illustrated in Fig. 2. This contains triple pole contactors for the primary (rotor) and secondary (stator) circuits. There are also two double-pole reversing contactors for the brush-shifting motor and a push button control to give "start,"

"stop," "creep," "raise speed," and "lower speed." The speed at any moment is indicated on a British Thomson-Houston electric tachometer.

Further examples of motors of this class are illustrated in Figs. 3 to 5 on pages 658 and 659. In the two examples shown in these figures, it will be seen that brush shifting is carried out by a hand-wheel instead of by the pilot motor as in the example shown in Fig. 1.

The constructional features of motors of this class are simple and robust, being somewhat similar to those of the familiar induction motor. On the rotor are two windings, the primary and the regulating, wound in the same slots. The supply leads are connected to slip rings, and thence the current goes to the primary winding, which is wound in the bottom of the slots. The regulating winding is of the closed drum type, and is connected to the commutator bars. On the stator is the secondary winding, which is arranged in a number of phases, both ends of each phase being brought out and connected to the commutator brush gear, which consists of two separate rings capable of being moved in opposite directions by rack and pinion mechanism. The starting ends of all the secondary phases are connected to the corresponding brush arms on one ring, whilst all the finishing ends are connected to similar brush arms on the other ring. Fig. 6 on page 659 represents the windings diagrammatically and shows how they are connected, while Fig. 7 is a Vector diagram for the motor running below synchronism.

As is well known, the slip of an induction motor depends on the torque developed, therefore the secondary E.M.F., which is zero at synchronous speed and maximum at standstill, must be of such magnitude as is required to produce the necessary current in the secondary circuit. If another E.M.F. in phase with this secondary E.M.F. were injected into this circuit, the slip would have to increase in order that the latter should be capable not only of producing the necessary current, but also of overcoming this injected E.M.F. In the Type C.H. motor this injected E.M.F. is obtained from the commutator and can be varied in value from a maximum in one direction to a maximum in the opposite direction, thus giving the minimum and maximum running speeds of the motor. When the brushes connected to the ends of each phase are opposite one another axially, the starting windings are short-circuited on the segments of the commutator, and the motor runs near its synchronous speed, like an ordinary induction motor. The injected E.M.F. is obtained by moving the brush gear by means of the mechanism already described, and it is evident that the direction of this E.M.F. will be determined by the direction of the movement, and its magnitude by the extent of the movement. Thus the speed above or below synchronism at which the motor operates may be adjusted as required.

The position on the commutator at which the brushes are coincident has a great effect on the characteristics of the machine. As the phase of the E.M.F. injected from the regulating into the secondary circuit is determined by this brush position, and the phase of the E.M.F. induced in the secondary winding is determined by the arrangement of the winding in the stator slots, the angle between the two E.M.F. components in this closed circuit can be altered at will simply by displacing the brush axis. By judicious choice of the brush position, high power factor, overload capacity and starting torque can be maintained at all speeds. This choice is carefully made and the position fixed while the machines are being built. The brush axis can be altered by suitable gearing at the same time as the brushes are being separated, so that power factor improvement can be obtained at all speeds of the motor. In every instance the operator only has to turn the handwheel, or control the brush shifting motor, in those installations where one is provided, in order to obtain the desired speed, which will be given under the most efficient and satisfactory conditions. Curves showing the relationship of power factor to torque at various speeds of a C.H. type motor rated at 80 h.p. to 27 h.p., 720 r.p.m. to 240 r.p.m., 440 volts, 50 cycles, are reproduced in Fig. 8, no attempt having been made in this case to improve the power factor at synchronous speed (500 r.p.m.). It will be observed that the power factor is practically unity at top speed over a considerable range of load. Moreover, it remains substantially at this figure over a large part of the range between top speed and synchronous speed.

The efficiency of the motor is high over the whole speed range, as may be noted from the curves in Fig. 9, while Fig. 10, below, enables an interesting comparison to be made of the losses involved at constant torque in obtaining the speed range by this B.T.H. motor and by the ordinary induction motor controlled by rotor resistance. The induction motor takes the same input at any speed, while the C.H. type motor takes only an amount which is approximately proportional to the speed, and thereby effects a large saving in power. These

Fig. 10. COMPARISON OF LOSSES IN OBTAINING SPEED VARIATION BY A.C. COMMUTATOR MOTOR, TYPE C.H. & BY INDUCTION MOTOR WITH ROTOR RESISTANCES.

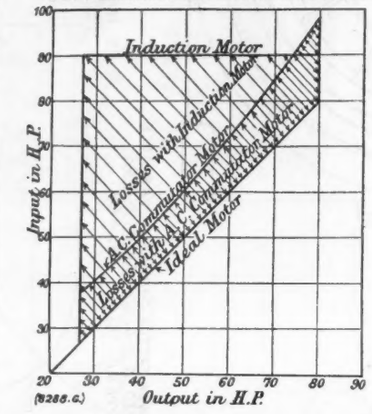
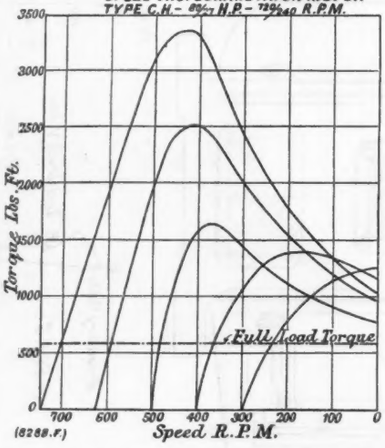


Fig. 11. SPEED-TORQUE CURVES OF VARIABLE SPEED A.C. COMMUTATOR MOTOR TYPE C.H.- 80 H.P.- 720/240 R.P.M.



facts are graphically represented in Fig. 10. Further, the speed-torque characteristics of the induction motor with rotor resistances are very steep, as the light running speed, whatever be the value of the resistance connected in the secondary circuit, is always practically its synchronous speed. Thus, for variations in load, corresponding variations in speed result.

From the speed-torque characteristics of the motor, of which an example is given in Fig. 11, it can be seen that any light running speed between zero and the limit for which the machine is designed can be obtained, and also that only slight change in speed results from a change of load (between light load and full load) with a fixed brush position. As previously stated, the standard speed range is usually 3 to 1, but lower speeds can be made available if desired. Very low speeds for "inching" purposes can be obtained by inserting resistance in the secondary circuit. A most important feature of this type of motor with a 3 to 1 speed range lies in the fact that it can be started up without the use of starting resistances.

From the foregoing description it will be noted that, if the brushes are set for minimum speed, the machine may be thrown straight on the line, as there will be present a regulating E.M.F., which will reduce the starting current. Actually it is possible for a motor to exert a torque of one and a-half times the full load torque, when switched straight on the supply mains, and yet take only a current of approximately full load value. Greater starting torque than this can be provided if desired. The commutation of this type of motor is good. The power dealt with by the commutator is only a fraction of the total developed by the motor (being in every case the "slip power"), so that the commutator can be designed very liberally, both E.M.F.s and currents being kept low. Thus the likelihood of insulation and commutation troubles is reduced to a minimum, and it is almost impossible to produce a flash-over under any working conditions.

THE ELEMENTS OF MAGNETIC ANALYSIS.

By ELLIS H. CRAPPER, M.Eng., M.I.E.E.

(*Continued from page* 602.)

INASMUCH as the relationship existing between the reciprocal of the susceptibility, $\frac{1}{\kappa}$, of a magnetic material and the magnetising-force H is a linear one (see page 601 *ante*) practically throughout the entire range of magnetisation, an example will now be introduced giving the method of deriving Fröhlich's equation from the results of tests in the form of $\frac{1}{\mu - 1} = a + b\,H$, or of $\frac{1}{\kappa} = \alpha + \beta\,H$. Satisfactory values of α and β are readily obtained from three or four sets of the values of H and I associated with each example tested, together with the derived quantities $\frac{1}{\kappa}$, $H \times \frac{1}{\kappa}$ and H^2. By arranging these values as in Table II, the respective summations $\Sigma\,H$, $\Sigma\,\frac{1}{H}$, $\Sigma\left(H \times \frac{1}{\kappa}\right)$ and $\Sigma\,H^2$ enable one by the application of the principle of the Method of Least Squares to form two simultaneous equations—in terms of α and β, and the summations shown in the table—from which the values of α and β are determined by the usual methods. In the case of magnetically hard steels, the author prefers to deal with the relationship existing between the intensity of magnetisation I and the magnetising-force H, in preference to that between the ferric-inductivity $B_i = B - H$ and H, inasmuch as it deals directly with the nature and condition of the material.

From these summations two simultaneous equations are formed as follows:—*n* being the number of constants included in the respective summations:—

$$\left.\begin{aligned} \Sigma\,\frac{1}{\kappa} &= n\,\alpha + \Sigma\,(H)\,\beta \\ \Sigma\left(H \times \frac{1}{\kappa}\right) &= \Sigma\,H \times \alpha + \Sigma\,(H^2)\,\beta \end{aligned}\right\}$$

The values of H and I in Table II are taken from a test on a sample of cobalt steel, and from the summations $\Sigma\,H$, $\Sigma\,\frac{1}{\kappa}$, $\Sigma\left(H \times \frac{1}{\kappa}\right)$ and $\Sigma\,(H^2)$ the required equations are as follows:—

$$\left.\begin{aligned} 1{\cdot}1157 &= 3\,\alpha + 2032\,\beta \\ 819{\cdot}21 &= 2032\,\alpha + 1493486\,\beta \end{aligned}\right\}$$

whence $\beta = 0{\cdot}000542$ and $\alpha = 0{\cdot}004785$;

hence the equation is $\frac{1}{\kappa} = 0{\cdot}004785 + 0{\cdot}000542\,H$.

Attention must also be drawn to the fact that there are three values of α and β for each sample of magnet steel, according as the test values correspond to the ascending (I / H) curve, the positive descending curve (*i.e.*, from H_{max} to H_c) or the positive return curve, associated with the upper half of the hysteresis loop. Thus, in the case of a sample of tungsten steel the following equations were obtained:—

For the I / H ascending curve,

$$\frac{1}{\kappa} = 0{\cdot}05078 + 0{\cdot}000759\,H$$

For the positive descending curve.

$$\frac{1}{\kappa} = 0{\cdot}028136 + 0{\cdot}000852\,(H + H_c)$$

For the positive return curve,

$$\frac{1}{\kappa} = 0{\cdot}02224 + 0{\cdot}000846\,(H - H_c)$$

For the demagnetisation portion,

$$\frac{1}{\kappa} = 0{\cdot}02697 + 0{\cdot}001011\,H_c$$

In connection with the equations for another sample of steel, Fig. 11 is introduced to indicate how closely parallelism exists between the linear representations of the three equations for a given sample of steel.

It must be mentioned here that in order to obtain the best results from tests on magnet steels the maximum value of the magnetising-force H_{max}, applied must not be less than a certain definite value, which may be fixed at 500 C.G.S. units for tungsten steels and 1,500 units for cobalt alloys. The importance of applying high values of H_{max}. is emphasised by the series of descending curves, given in Fig. 12, for values of $H_{max} = 95$, 130, 165, 210 and 250 C.G.S. units in the case of tungsten steel. In a similar manner the curves A, B and C in Fig. 13 for a sample of cobalt steel bring out clearly the same feature, and it is interesting to note the following details :—

when $H_{max} = 1500$, $H_c = 200$, $I_r = 810$, $H_c/I_r = 0{\cdot}2469$
$H_{max} = 600$, $H_c = 194$, $I_r = 784$, $H_c/I_r = 0{\cdot}247$
$H_{max} = 400$, $H_c = 175$, $I_r = 694$, $H_c/I_r = 0{\cdot}255$

In this case the linear equations were :—

(A) $\frac{1}{\kappa} = 0{\cdot}04123 + 0{\cdot}00076\ (H + H_c)$

(B) $\frac{1}{\kappa} = 0{\cdot}0334 + 0{\cdot}000833\,(H + H_c)$

(C) $\frac{1}{\kappa} = 0{\cdot}0559 + 0{\cdot}00083\ (H + H_c)$

Then, again, the fact that the reciprocal of β is, from first principles, equal to the magnitude of the saturation intensity, I_s, of the material, the effect of varying the percentage of the essential element forming the alloy is readily ascertained when the linear equations have been obtained. Professor Honda of Tokio University, Japan, published in 1919 the results of his investigations on a commercial series of cobalt alloys, and proved that whilst values of remanent intensity corresponding to the best tungsten steels are readily obtained, coercive forces from 200 to 240 units are secured by correct heat treatment. From the published results of Honda's researches, the author has derived Fröhlich's equations for the complete range of tests, and gives, in the accompanying Table III, the change in the value of the saturation intensity, I_s, as the percentage of cobalt is changed. Fig. 14 shows graphically how I_s changes as the composition is changed.

Every alloy has a definite saturation intensity of magnetisation, corresponding to its actual physical condition when under test, and is by its nature additive, and is equal to the *sum* of the individual saturation intensities of all the molecules. Professor Weiss of Zurich, as long ago as 1912, announced that "*the saturation intensity of the* 35 *per cent.* Co *of the alloy*, Fe_2 Co, *is* 10 *per cent. greater than that of pure iron*, and this is in good agreement with the values given in Table III. Weiss also states that, at very low temperatures, I_s varies as a linear function of the composition.

When one investigates the magnetic properties of a magneto-magnet, and endeavours to determine the relationships existing between the various magnetic quantities involved in the working and operative qualities of the magneto, it is soon realised that there is no single-valued constant of a magnet which characterises its suitability as the essential element of the magneto. The author, therefore, suggests that considerable advantage may be obtained by introducing a system of *derived* constants, consisting of the products or quotients of two single-valued constants.

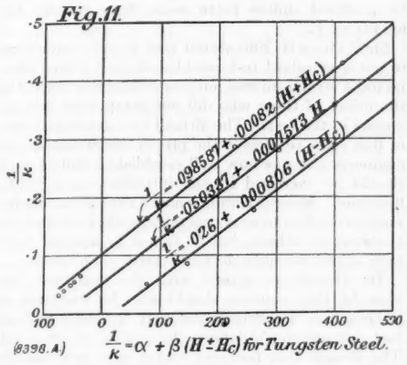
It is universally recognised that the magnetic behaviour of magnetisable materials when subjected to magnetising forces is a complex quantity, depending on the chemical constitution, condition and form, the previous history and the thermal treatment of the steel during the several processes involved in the production of the magnet. The complexity is furthermore accentuated in consequence of their special shape which give full scope to the introduction of irregular strains whilst the material is being cogged, rolled, bent, hardened, ground and the holes drilled, operations which give rise to lack of uniformity in quality and of hardness of the finished magnet.

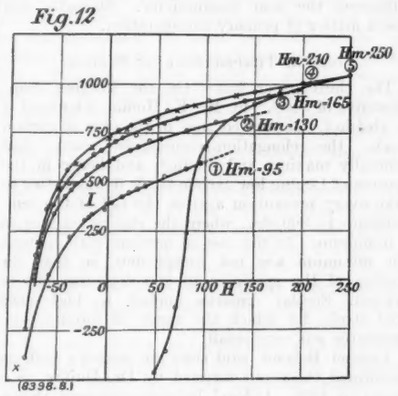
The operative behaviour of a magneto-magnet is the resultant effect of the various physical and mechanical properties of the material according to its condition. The characteristic feature of a permanent magnet steel is its property of developing a structural magneto-motive-force (M.M.F.) when under the influence of a suitably applied magnetising-force, a considerable portion of which is retained in the form of a remanent magnetic flux after the applied magnetising force has been removed, thus endowing the magnet with large coefficients of coercivity and hysteresis. This inherent M.M.F. of a permanent magnet is the *cause* of the transference of magnetic fluxes both through the metal and through the air-gap in the case of open-circuit conditions, and the magnitude of the remanent intensity of the flux varies inversely as the *joint reluctance* of the complete circuit. In other words, a permanent magnet is analogous to an electric battery of constant E.M.F., the current output of which is dependent upon the external reluctance of the circuit.

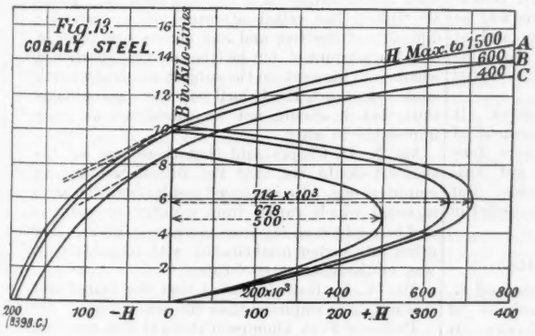
Attention has already been called to the fact that the complete descending positive portion of the hysteresis loop is a hyperbolic function of the demagnetising-force $(H + H_c)$, *i.e.*, that by plotting the consecutive values of the reluctivity $\frac{H + H_c}{B}$ against the corresponding values of $(H + H_c)$, a

TABLE II.

H	I	κ	$\frac{1}{\kappa}$	$H \times \frac{1}{\kappa}$	H^2
437	1809	4·139	0·2416	105·58	190969
674	1820	2·700	0·3703	249·60	454276
921	1828	1·985	0·5038	464·03	848241
$\Sigma H = 2{,}032$	——	——	$\Sigma \frac{1}{\kappa} = 1{\cdot}1157$	$\Sigma\left(H \times \frac{1}{\kappa}\right) = 819{\cdot}21$	$\Sigma (H^2) = 1493486$







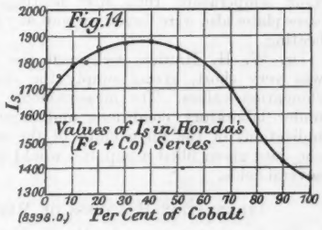


TABLE IV.

Tester readings	65	66	66	67	67	67	67	68	68	69
$c = \frac{B_r}{B_{max}}$	0·656	0·656	0·673	0·646	0·66	0·663	0·665	0·668	0·667	0·67

TABLE III.

Composition.	Fröhlich's Equations.	I_s
Fe	$\frac{1}{\kappa} = 0{\cdot}00802169 + 0{\cdot}0005908\ H$	1667
(per cent.) 5 Co	$\frac{1}{\kappa} = 0{\cdot}011866 + 0{\cdot}0005736\ H$	1742
10 Co	$\frac{1}{\kappa} = 0{\cdot}010592 + 0{\cdot}0005614\ H$	1781
15 Co	$\frac{1}{\kappa} = 0{\cdot}0131503 + 0{\cdot}0005563\ H$	1797·6
20 Co	$\frac{1}{\kappa} = 0{\cdot}0098482 + 0{\cdot}0005375\ H$	1858·6
30 Co	$\frac{1}{\kappa} = 0{\cdot}0049845 + 0{\cdot}0005351\ H$	1868·8
40 Co	$\frac{1}{\kappa} = 0{\cdot}0053147 + 0{\cdot}0005339\ H$	1873
50 Co	$\frac{1}{\kappa} = 0{\cdot}004785 + 0{\cdot}0005421\ H$	1844·7
70 Co	$\frac{1}{\kappa} = 0{\cdot}0150285 + 0{\cdot}0005884\ H$	1699
80 Co	$\frac{1}{\kappa} = 0{\cdot}0148229 + 0{\cdot}0006432\ H$	1544·7
90 Co	$\frac{1}{\kappa} = 0{\cdot}0251278 + 0{\cdot}0007098\ H$	1422·6
100 Co	$\frac{1}{\kappa} = 0{\cdot}161115 + 0{\cdot}0007355\ H$	1359

straight line is obtained, giving Fröhlich's equation as $\frac{H + H_c}{B} = \alpha + \beta (H + H_c)$. Furthermore, the *rate of change* in the *slope* of the descending curve of the hysteresis loop is a critical measure of the nature and condition of the material, and this, to a certain extent, may be indicated by the ratio $\frac{B_r}{B_{max}}$ or $\frac{I_r}{I_{max}} = c$, known as the *coefficient of retentivity* of the magnet. It may not be known that in the Bosch magnetic tester—which was largely used during the war period—the scale consisted of a series of numbers which expressed the minimum values of the coefficient of retentivity, $c = \frac{B_r}{B_{max}}$ or $\frac{I_r}{I_{max}}$, for the different sizes of the magnets of the magneto, which were acceptable. Table IV, on page 661, gives the results of calibration tests, made ballistically, upon a Bosch magnetic tester by means of a series of ten (No. 65) magneto-magnets.

To differentiate between the values of the workshop tests of the coefficient c and the values of the ratio $\frac{I_r}{I_s} = c_s$, *i.e.*, the *specific coefficient of retentivity*, we have, as the measure of the susceptibility at the remanency point of the curve,

$$\kappa_r = k_r (I_s - I_r) = k_r (I_s - c_s I_s) = k_r I_s (1 - c_s)$$

indicating a critical relationship between the saturation intensity, susceptibility and the specific coefficient of retentivity c_s.

When it is required to make standard tests on horse-shoe magnets under closed-circuit conditions, it is necessary to use a massive keeper of wrought-iron, and it is interesting to ascertain ballistically, or by means of a flux-meter, what change occurs in the magnitude of I_r when the keeper is detached. The new value of the remanent intensity is I_{r1}, —termed the *open-circuit remanence*—and the derived relationship, $\frac{I_{r1}}{I_r}$, a type of coefficient of retentivity, is an indication of the nature of the slope of the demagnetising portion of the curve.

Furthermore, the nature of the curvature of that portion of the cyclic diagram between the remanence and coercivity points is more productive of information, so far as permanent magnets are concerned, than any other part of the loop. Thus, the area enclosed by it and the two axes is the measure of the energy stored in the field, and is, in ergs, equal to $\frac{B H}{8 \pi} \times$ volume of the magnet, in consequence of the energy which is absorbed by the steel during the process of magnetisation as the result of molecular friction, with which is associated magnetic hysteresis, *i.e.*, the *lagging behind* of the magnetisation relatively to the magnetising-force H. Hysteresis is one of the factors which dominates the form and size of the complete loop of the cyclic diagram, and thus is an element which fixes the position of the remanence point on the B-axis, as well as the intercept made by the curve on the H-axis to the left of the B-axis. This intercept is the measure, in units of H, of the reverse or negative magnetising-force which is required completely to remove the remanent magnetism possessed by the sample, for which reason it is termed the *coercive-force* or *coercivity* of the material.

(To be continued.)

THE IRON AND STEEL INSTITUTE.

(Concluded from page 633.)

WE give in the following a précis of the final proceedings at the meetings of the Institute on Friday, the 9th inst.

REVERSING REGENERATORS.

The second paper taken on Friday morning had for its title "Theoretical Considerations respecting certain Features in the Working and Efficiency of Reversing Regenerators," by Mr. J. Seigle, in whose absence it was taken as read. The paper is one which does not lend itself to abstracting. The considerations it entered into served to show how difficult it was in practice to study the comparative efficiencies of given regenerators by taking as a basis the effective measurement of the temperatures and of the weights of the fluids, and how difficult it was to ascertain separately the influence of any given dimension or any given arrangement of the regenerator itself, and also to ascertain accurately the part played by radiation losses. The exact determination of the actual average temperatures of the fluids, independently of the influence of the radiation from the walls upon the recording instruments, was in itself a source of considerable difficulty.

Mr. R. Whitfield asked in connection with this paper and the preceding one whether brickmakers could make a brick of which he drew a section on the blackboard, to maintain a better heat in the regenerators. The shape he wanted was like the section of a sharp angle bull-headed rail.

Mr. H. M. Ridge said the thanks of the Institute were due to Mr. Seigle for contributing to our knowledge of what took place in the bricks of a regenerator. His contribution would afford assistance in future research work, as there was still much to learn as to the effect of heat on bricks. The paper was difficult to discuss. It did not give the analysis of the bricks, but stated that they were an aluminosilicate, which did not carry one very far, since the quality for furnaces and for regenerators varied enormously. Small differences in quality greatly influenced the heat conductivity. Strength was also a matter of primary consideration.

FORGING TEMPERATURE OF STEELS.

The third paper was "On the Forging Temperatures of Steel," by Mr. K. Honda, who read it in abstract. It showed that in the case of carbon steels, the elongation-temperature curve had generally maxima and minima, and hence in the process of forging low carbon steels it was better to take every precaution against the fall of the temperature to 900 deg. where the elongation was at a minimum. In the case of medium carbon steels the minimum was not conspicuous, so that the cooling of the specimen to 900 deg. was not so critical. Similar remarks applied to high-speed tool steels, for which the range of forging temperatures was very small.

Colonel Belaiew said that the author's findings confirmed those put forward by Dr. Dupuy, in a paper in 1921. Colonel Belaiew instanced Damascene steels which were forged in the same way as that outlined by the author, first slightly and at room temperature, then after heating. In some cases plates also were forged without any substantial heating.

Dr. W. H. Hatfield welcomed the paper. It was very short, giving simply the statement of elongation values. The measurements were done under laboratory conditions and were not final indications of the forgeability of the steels. But the data given filled a gap and would be useful in several fields.

INDENTATION HARDNESS OF METALS.

The fourth paper was by Mr. K. Honda and K. Takahasi, "On the Indentation Hardness of Metals." It was read in abstract by the former. It stated that in the usual method of recording Brinell hardness, the impression was measured after the load was removed; with hard metals, especially quenched steels, the recovery of the impression, after unloading was considerable, and the hardness figure could not be relied upon. The Brinell hardness measured during the application of the load was quite correct. The paper gave formulæ for hardness.

Mr. W. F. Beardshaw said he was using the Brinell hardness test more and more, and was greatly interested in the author's new definitions. He found the test as now carried out quite satisfactory, but if the authors brought out an improvement on it he would give the improvement his welcome.

Professor Sauveur, dealing with Mr. Honda's first paper, said he had been carrying out experiments on much the same lines, but by twisting bars in an electric furnace open at both ends, in which the maximum temperature was at the centre. The bars were twisted by a simple device until fracture occurred. He found every time that the fracture did not take place where the temperature was the highest. The twists were at two equidistant points and the bar broke at one of them. The critical twists met together when the temperature was 900 deg. C. showing a critical plasticity at the A3 point. Armco iron was more plastic at 900 deg. than at 1,000 deg. He had obtained similar results to Mr. Honda's by tensile work, also by compression. Heating at the centre did not lead to collapse at the centre, but at two points equidistant. This showed that when iron underwent allotropic transformation it assumed a critical plasticity.

BRINELL-TENSILE RELATIONSHIP.

The fifth paper taken on Friday morning had reference to "Experiments on the Brinell-Tensile Relationship," by Mr. A. L. Norbury and Mr. T. Samuel. It compared tensile, Brinell and scleroscope tests, and was taken for discussion with the former paper.

Mr. Norbury, dealing with the paper by Messrs. Honda and Takahasi, asked how the depth of identation was measured, as the depth could be measured in two ways, either in the centre of the indentation, taking in a ridge formed around it, or from the outside, level with the outside surface of the material. That might perhaps explain differences in the results obtained by Mr. Honda.

Dr. W. H. Hatfield said the Brinell test was reliable and was now standardised, and should not be modified unless there were deep reasons for modifying it.

Sir William H. Ellis stated that it took some time to get a standard test established, and during that period a wrong impression was sometimes created in the minds of those who did not grasp what was involved in the test. The Brinell test had taken four or five years to receive the proper understanding of engineers; it was now well established and caution should be exercised in the introduction of modifications. Messrs. Honda's and Takahasi's remarks might be taken to cover certain pcints that had not occurred to others, but if taken in another light they might possibly do more harm than good.

Dr. Rosenhain agreed with the chairman, but thought that caution should also be exercised in adhering to the Brinell test. It was an empirical test, not one which defined the quality of the metal. The Brinell test, however useful, was only roughly approximate. A great difficulty also came in when the deformation of the ball itself took place. Mr. Honda had called attention to a particular difficulty of the test and had shown how it could be taken account of, but he (the speaker) questioned whether all his work on the subject was really worth while. In short, the Brinell test was a good makeshift, but it should not be considered as being impossible to alter.

Mr. N. D. Chopra said that there was not the slightest doubt but that the Brinell test was an empirical one. He instanced results from the same material which varied from country to country, and he might even say from morning to night. The going into higher mathematics with reference to it was, he thought, waste of time.

Mr. W. H. Hatfield stated that the Brinell test was not more empirical than the tensile test.

Professor F. C. Thompson thought that the work by Messrs. Honda and Takahasi was not intended to oust the Brinell test, but to get more from it than was now the case. The authors had given for most metals the relation between the load P and the depth of impression h; it was not clear to him (the speaker) whether this was empirical or not. Their present mathematical work followed obviously from the empirical nature of the original work, which he assumed was not mathematical; but all this did not detract from the value of the work that centred round the Brinell test.

Colonel Belaiew stated that it was not very important whether the Brinell test gave or not the definition of a physical constant. What was important was that if intelligently applied it always gave a measurement of one and the same thing. The Brinell test was quite firmly established, but there should not be asked of it what it was not intended to give. He (the speaker) used it for testing pieces that had to be kept intact, to ascertain their homogeneity, and the results it gave were excellent. Properly applied, the test had a great technical as well as a great practical value.

Dr. L. Aitchison, dealing with Mr. Honda's paper on forgings, said its title was not applicable, since

the author had used the measure of the elongation test; this information did not square with forging practice.

TRANSVERSE TEST-BARS AND FORMULÆ.

The first paper taken at the meeting on Friday afternoon, the 9th inst., dealt with "Transverse Test-Bars and Engineering Formulæ," by Messrs. G. S. Bell and C. H. Adamson. It was read in abstract by the former.

The authors pointed out that the generally accepted engineering formulæ for the conversion of the transverse test on a bar to that on another sized bar did not hold when applied to cast-iron test-bars of different sizes. Their paper covered tensile and other tests, and the effect of machining on transverse strength.

Dr. L. Aitchison gave instances in which the formulæ could, and could not, apply, adding that cast iron had not a constant modulus of elasticity, this varying by something like 50 per cent. between the minimum and maximum values. In regard to machining, one would expect the variations found as a result of this. Piston rings were tested in the past by ascertaining the breaking stress of a separately cast piece or of a piece taken from an extension of the cylinder from which the rings were cut. Now pieces were cut out from the piston ring pot itself and the results were constant. There was close relation between the results given by the two methods, which would indicate that the engineering formulæ could be used, but these did not give consistent results when translated to different sizes.

Mr. E. Adamson thought the last speaker had scarcely given the authors full credit for their work; they were referring to engineering castings and not to piston rings, the engineering castings being from 1 in. to several inches in thickness, and the test-bars those which had been used for a long time in the trade. The paper was an eminently practical one, and the research had been carried out in the foundry under ordinary working conditions. He (the speaker) had long since come to the conclusion that chemical analysis played only a small part in the testing of cast iron, and cast iron cooled rapidly gave a higher test than that slowly cooled. The paper confirmed these points, and its value had been proved in the engineering world by inspectors who had based their inspection work upon it. He (the speaker) agreed with the paper on "High-Temperature Growth of Special Cast Irons," by Professor J. H. Andrew and Mr. H. Hyman (which had been taken as read), in its statements to the effect that "cast iron was perhaps the most complex and least understood of all iron-carbon alloys," hence "it was not always possible to compare the work of different observers in the hope of complete agreement." The paper by Messrs. Bell and Adamson was a strictly parallel one to it. He was glad that Messrs. Bell and Adamson had confirmed his (the speaker's) paper read in 1909, in that he had proved that when the test-bars were machined, just "skimmed off," they gave 10 per cent. better results. The authors' present results would not perhaps enable them to give new formulæ, but their further work might lead them to do so.

Professor Louis said he had built thirty-five years ago a testing machine for foundry work and was very glad to see that further progress was being made.

In the course of his reply, Mr. G. S. Bell stated he was sorry if Dr. Aitchison had the idea that the authors threw doubt upon the formulæ simply on account of the age of the latter, for such was not the case. They had been given by the authors simply owing to their importance; they were most widely used on the engineering sides of the universities, and for that reason they had been selected. Machining by removing the irregularities on the surface led to increased strength, but if machining went far down it opened up the structure and weakened the piece. Inspectors had passed a bar as a result of the authors' research, and this would not prove useless if its results found application in ordinary foundry routine.

SILICO-MANGANESE STEELS.

The second paper taken on Friday afternoon had reference to "The Hardening of Silico-Manganese Steels," by Mr. E. W. Colbeck and Dr. D. Hanson. It was read in abstract by the former. It showed that the temperatures required for complete hardening of the steels used were very much higher than the corresponding hardening temperatures for straight carbon steels having the same carbon content. The steels used were Siemens acid open-hearth, typical of British spring steels, containing in one instance carbon 0·39, silicon 1·98, manganese 0·885 per cent., and in the other, carbon 0·50, silicon 1·5, manganese 0·865 per cent.

Professor J. H. Andrew thought that the paper would be found most useful in actual practice. His only remarks applied to the authors' determination of the critical points, namely, their statements to the effect that "the liquidus occurred at 1,464 deg. C., and the delta-gamma transformation at 1,421 deg. C.," to which he (the speaker) did not agree, for these particular steels; he suggested different change points and referred to the magnetic change point which occurred as a result of adding silicon, also to the change found on heating at 700 deg. C. and due to the breaking down of the carbide.

Dr. Rosenhain said that in existing literature many statements on alloy steels could be found which were not so accurate as they might be and did not appear to be borne out by facts when these were carefully observed. The authors' paper threw light on the behaviour of these particular steels on hardening and gave a lead to their further investigation. Professor Andrew might be right or not in some of his suggestions, for the part played by carbon was not known for certain, nor whether the carbide of iron did decompose at those temperatures. There was need for much more extended investigations to elucidate many points.

Mr. D. Lewis said he was able to confirm the authors' findings as to the effect of silicon upon steel. His own work was not done on similar steels, but on stainless steels containing a relatively high percentage of chromium, and to which silicon was added; the effect of the silicon was the same as that in manganese steels. Mr. Lewis drew three heating curves on the blackboard for chromium steels, low in carbon and with increasing amounts of silicon, showing the A.C.1. and magnetic changes; the A.C.1. point got higher and less pronounced with the increase in silicon, the rising temperatures being 821 deg., 842 deg. and 885 deg. C., at the latter temperature the silicon being 1·3 per cent., lower therefore than the percentage in the authors steels. The effect was therefore an important one. He (the speaker) quenched at a higher temperature than the authors. The Brinell number varied with the quenching temperature. The amount of silicon present was an important point to be taken into account in the tempering of these steels.

Colonel Belaiew referred to the work by Grenet and asked whether the gamma to delta transformation occurred quite close to the zero line; he would like to have more data on that point.

Mr. W. T. Griffiths said that his own results would seem to show that even the dilatometer was not quite suitable to record the changes, although it had the advantage of showing very definite points. With stainless steel low in silicon there was a marked contraction at the Ac point, but with increasing silicon the contraction was slighter, and one was not sure whether that marked the total change. Silicon had two effects; it raised the point on heating and spread it out, but on cooling the corresponding Ar point was depressed. The effect of silicon seemed to be different from that of chromium, to be in the opposite direction. The absence of cracks in high silicon steel was an interesting feature brought out, and the authors' work gave a better idea than hitherto available of what really happened in these alloys.

Dr. L. Aitchison thought the authors' work would appeal to spring steel makers, since it was difficult to standardise the heat treatment and the mechanical properties of steel used in the manufacture of laminated springs. It was always difficult to decide whether a spring failed through lack of ductility or lack of strength, and the authors' paper would afford an aid to the spring making industry. He confirmed the remarks made by Mr. Lewis.

In the course of his reply, Dr. Hanson said the authors thought the transformation at 1421 deg. C. was the delta to gamma transformation, and not alpha to gamma, which began at a lower figure, 1100 deg. C. They knew that in high silicon steel the alpha to gamma transformation point was raised considerably, but how far it was raised for any amounts of silicon they had not ascertained and could only speak for the steels they had dealt with. He (Dr. Hanson) agreed with Dr. Rosenhain that there was nothing much to show when carbon commenced to break down, but so far as their (the authors') steels went, dissolution was approximately at the A_1 transformation point, and only in a portion of the iron. The authors were glad to find by the remarks of Mr. Lewis that they were in agreement with him. Dr. Hanson confirmed in reply to Colonel Belaiew that the transformation at 1421 deg. C. was the delta to gamma transformation.

ELECTRO-DEPOSITION.

The third paper, taken on Friday afternoon, was on "The Hardness of Electro-Deposited Iron, Nickel, Cobalt and Copper," by Mr. D. J. Macnaughtan, who read it in abstract. It gave the Brinell hardness numbers of a range of different deposits; the conditions of deposition which, within certain limits, had been found to cause increase in hardness for the various deposits, and discussed the possible explanations of the high hardness of certain deposits.

Sir Robert Hadfield said the paper was interesting to him, since during the war one had to contemplate at one time not being able to obtain driving bands for our projectiles, and we knew that our enemies were using deposited iron for these. Now, in peace time, the question of deposited iron was one of great importance also. Here Sir Robert alluded to some deposited iron specimens he had obtained from Messrs. Bouchayer et Viallet, a French firm. This iron contained 0·08 per cent. of carbon and 0·02 per cent. of manganese, the rest being iron. His experiments showed that by heating it to 350 deg. C., the initial brittleness was removed. The first pronounced softening occurred between 350 deg. and 500 deg., but the toughening effect preceded this, *i.e.*, at a lower temperature. This treatment did not make the iron more hard. The specific gravity was not affected by the loss of hydrogen under this treatment. There was no apparent explanation to show why the presence of hydrogen caused electrolytic iron to be hard, and no other cause, other than the presence of hydrogen, was known to explain the original hardness of this metal. The Brinell hardness number, as received, was between 202 and 210; after heat-treating at 500 deg. for 15 minutes it fell as low as 159 deg. The specific gravity remained at the same figure, namely, 7·86, in both cases. He (Sir Robert) agreed with the author's statement to the effect that unequal distribution of dissolved hydrogen had been proposed as a possible cause of internal stress in iron deposits, and agreed when the author suggested such an explanation to be inadequate, in the case of nickel deposits, owing to the small amount of hydrogen found to be present. Sir Robert could not explain the changes in physical properties which took place whilst the specific gravity remained the same.

Mr. E. A. Ollard confirmed the importance of hardness in the matter of electro-deposits, the building up to size of a worn part in a piece of mechanism being one of the uses of the process. The harder a bearing surface was, the better it stood up. The Brinell hardness test was useful in many instances, but it did not reveal how a piece would wear. Nickel showed practically no corrosion compared with steel, and steel wore partly by erosion and partly by corrosion. He hoped to be able to carry out sand-blast tests and to gather from them information in regard to actual wear. In the actual deposition process the stirring of the solution might have an effect on hardness by reducing the crystal size. Firms in America had made a commercial success of the manufacture of electro-deposited iron. With reference to the author's statement as to steel strips bending when plated upon one side by hard deposits of other metals, he (the speaker) mentioned the instance of a forging which after thickening up with a layer of nickel was completely distorted. This pointed to the fact that distortion should be kept in mind in the case of certain pieces. He (the speaker) had obtained practically the same

4–6–0 LOCOMOTIVE FOR THE L.M.S. RAILWAY; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS, DALMUIR.

(*For Description, see opposite Page.*)

Fig. 41.

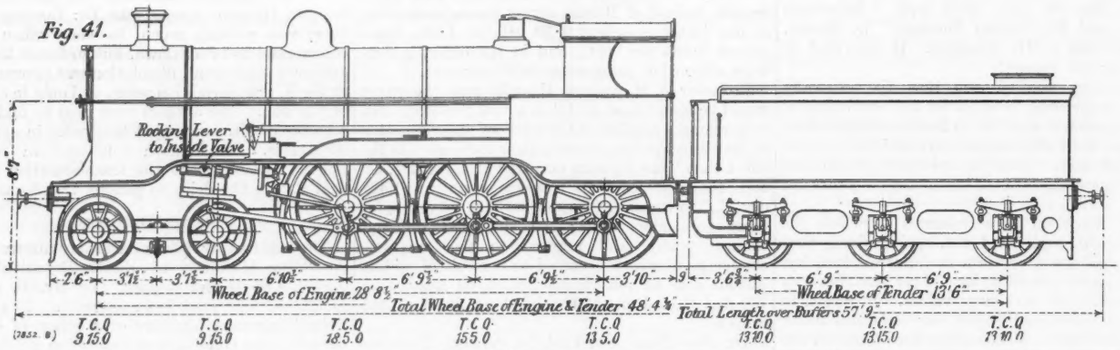

Rocking Lever to Inside Valve
Wheel Base of Engine 28' 8½"
Total Wheel Base of Engine & Tender 48' 4¾"
Total Length over Buffers 57' 9"
Wheel Base of Tender 13' 6"

Fig. 42.

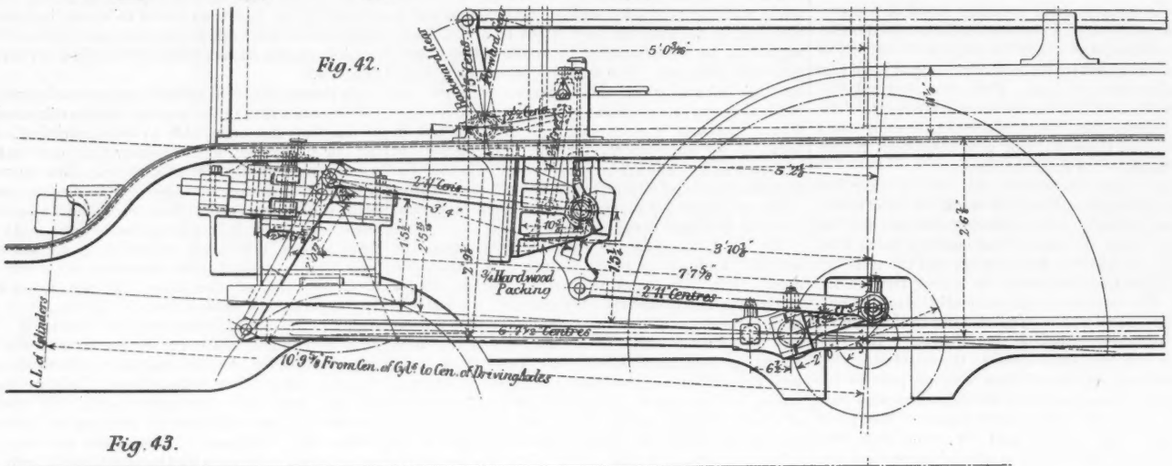


Fig. 43.

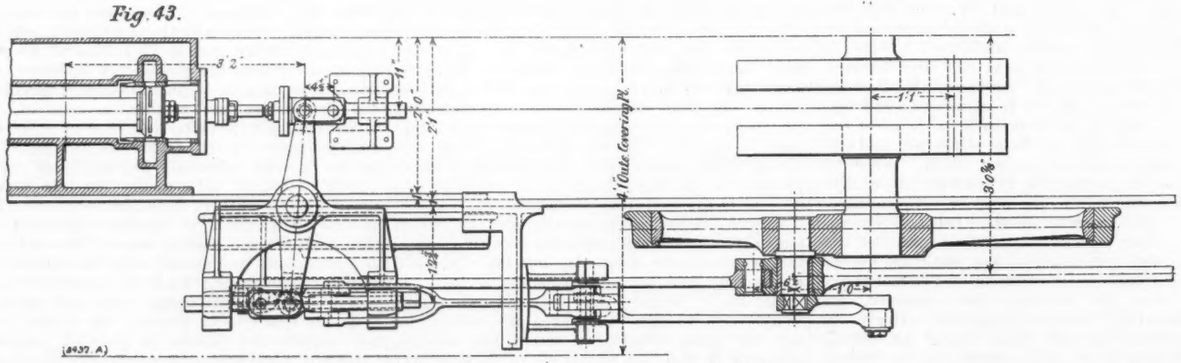


Fig. 44.

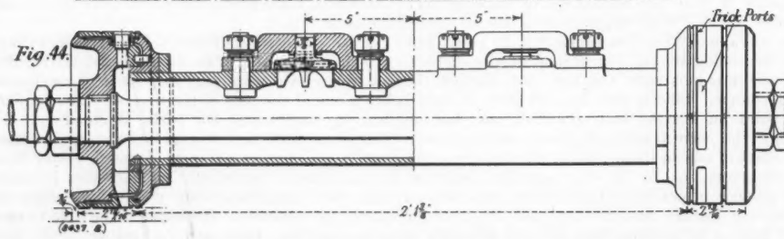
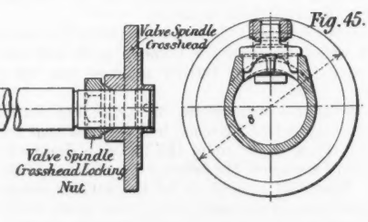


Fig. 45.



Brinell hardness numbers as those quoted by the author for iron and nickel deposits. With reference to hardness, this was, generally, greater the smaller the crystals, which also confirmed the author's findings. He (the speaker) added that he was now testing deposited nickel by the X-ray method to further investigate the crystal structure. Metal deposition for correction and building-up was gradually coming into use.

Mr. S. Field stated that, besides the applications of electro-deposition in the engineering domain, it also rendered great service in the printing trades by greatly increasing the number of impressions possible from one and the same block. Besides hardness and brittleness, it was necessary also to watch the tendency which the deposits had to curve and split away from the basis metal.

THE TESTING OF METAL STRIP.

The last paper taken on Friday afternoon, the 9th inst., was entitled, "Notes on the Testing of Metal Strip," by Dr. Leslie Aitchison and Mr. L. W. Johnson. It was read in abstract by the former. It recorded the test conditions stated in the British standard specifications, and gave an illustrated description of a machine for making the bend tests in conformity to those conditions, the machine being easy to work and reasonably cheap to make. It also dealt with a simple proof-stress extensometer and a proof-stress indicator. The notes were put forward with a view to simplifying and cheapening the testing of a very important material.

Dr. T. Swinden said he greatly appreciated the paper, for all the members knew how difficult it had frequently been in earlier days to correlate test-house results with those obtained in actual practice. The authors had done a useful piece of work by describing what they had done, and if their method could be extended to the testing, for

4-6-0 LOCOMOTIVE FOR THE L.M.S. RAILWAY; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS, DALMUIR.

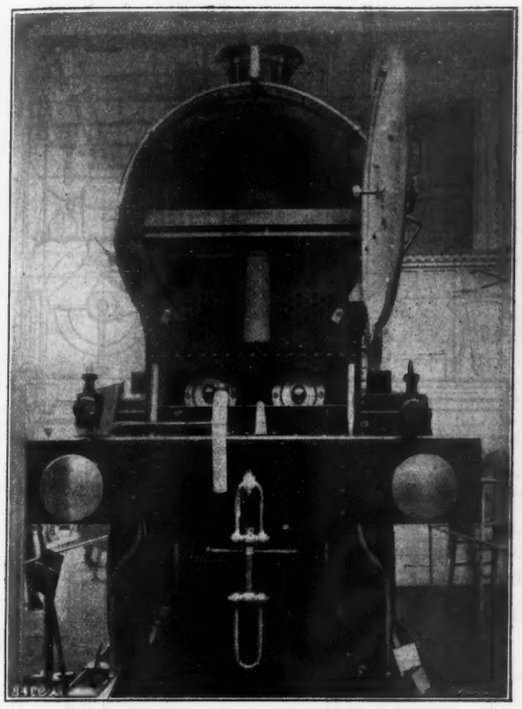


FIG. 46. FRONT END OF ENGINE.

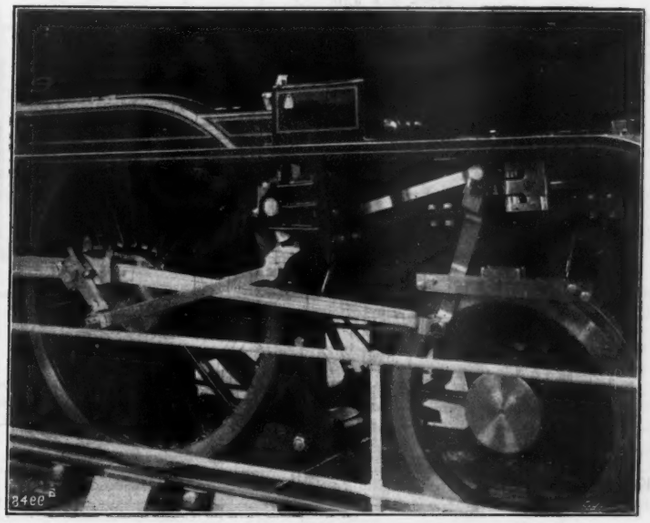


FIG. 47. VALVE GEAR OF ENGINE.

example, of aircraft strip its benefit would be well proved.

The other papers on the list were taken as read. The usual votes of thanks to the Institution of Civil Engineers for the loan of their premises, and to the chairman, concluded the proceedings.

BRITISH EMPIRE EXHIBITION; RAILWAY MATERIAL.—III.

THE London Midland and Scottish Railway is represented, in addition to its own exhibit of one of the latest pattern of third class coach, by an express passenger engine forming part of the exhibit of Messrs. William Beardmore and Co., Limited. This engine is one of an order being executed at the firm's Dalmuir works. It is of a type very similar to that illustrated in ENGINEERING about twelve months ago (vol. cxv, page 596), and is characterised chiefly by the fact that the design embodies an adaptation of the Walschaert valve gear to an engine with inside cylinders. The diagram, Fig. 41, page 664, shows the wheel base and distribution of the weight. The engine shown at Wembley is not quite identical with that illustrated previously in our columns and shown in Fig. 41, the later machines having a Belpaire firebox and slightly modified valve gear. The new gear itself is shown in Figs. 42, 43 and 47. It was developed by Captain H. P. Beames, the company's mechanical engineer at Crewe. The main features of the gear consist of the usual Walschaert return crank and eccentric, but the motion of the combination lever, usually taken from the cross-head, is, in this design, taken from a small connecting rod working off the leading end of the side rod. The combined motion derived from this rod and from the eccentric rod, drives a spindle sliding in guides, and from this is worked a rocking lever passing inside the frames and driving the valve spindle. The gear is much lighter than the ordinary Stephenson link type, though the need for the rocking lever, the small connecting rod, &c., make it heavier than the Walschaert gear as applied to outside cylinders. It appears to be giving good service on the London Midland and Scottish Railway, and engines fitted with it have many good performances to their credit. Fig. 46 shows the front end of the engine and below the smokebox may be seen the position of the piston valves.

The engine exhibited by Messrs. William Beardmore, to which this gear is fitted, has two inside cylinders 20½ in. in diameter and with a stroke of 26 in. The driving wheels are 6 ft. 3 in. in diameter, and the bogie wheels 3 ft. 9 in. in diameter. The boiler has a heating surface of 1,447 sq. ft. distributed between the tubes and firebox, there being 1,308 sq. ft. in the former and 139 sq. ft. in the latter. In addition there is superheating surface amounting to 304 sq. ft., the grate area being 26 sq. ft. The driving-wheel base is 13 ft. 7 in., and the weight on the coupled wheels 46 tons 15 cwt. out of a total for the engine of 66 tons 5 cwt. The tender weighs in working order 40 tons 15 cwt., the combined machine therefore having a weight of 107 tons, distributed over a total wheelbase of 48 ft. 4½ in., or total length over buffers of 57 ft. 9 in. The boiler pressure carried is 180 lb., and at 85 per cent. boiler pressure the maximum tractive force works out at 22,745 lb. Figs. 44 and 45 show the anti-compression valve designed by Captain Beames and fitted to the piston valves of this class of engine. The tender has a water capacity of 3,000 gallons, and carries 6 tons of coal. The tender wheels are 3 ft. 9 in. in diameter.

At the stand of the Drewry Car Company, Limited, whose works are at Burton-on-Trent, three typical examples of petrol-driven stock are shown. One of these is a narrow-gauge locomotive, a second is a standard 20-h.p. Drewry rail motor trolley to carry six people, while the third is a new pattern of light inspection motor trolley. The narrow-gauge locomotive is illustrated in Figs. 48 to 56 on pages 666, 667, and 672. It is built to a 60-cm. gauge, and the wheel base being 2 ft. 9 in. it can successfully negotiate very sharp curves. The general arrangement of the locomotive is clearly shown in Figs. 48 to 50. The under-body is constructed on steam locomotive lines, the frame plates being ⅝ in. and the buffer beams ¾ in. thick. The driving wheels are of cast steel 1 ft. 8 in. in diameter, the thickness of the treads being 1¾ in. The axles are of steel to main line specification, and they have journals 3 in. in diameter by 5½ in. long. All wheels are coupled and are driven by two cranks mounted on outside spur wheels, running loose on pins riveted to the frames near the leading end, as best seen in Figs. 54 and 55, page 667. These spur wheels are driven by pinions keyed to opposite ends of a straight shaft, as shown in Fig. 55. This shaft is fitted with a bevel reverse gear, one or other of the large bevels being secured to the shaft by a claw clutch according to the direction of motion desired. The whole of this reverse gear is enclosed in a casing, and is thus thoroughly protected from dust and dirt. The bevel pinion is mounted on the lower of the two longitudinal shafts visible in Fig. 54. It can be driven at two speeds by means of the change gear shown above it. With the engine making its designed revolutions per minute the two speeds available correspond to six and three miles per hour respectively. As will be seen from the drawing, the low-gear pinion is mounted on a solid shaft which passes through a hollow shaft, on which is keyed the high-gear pinion. Both the hollow and the solid shafts are fitted with friction clutches, either of which can be coupled to the engine shaft, giving the high or the low speed accordingly. The gears are thus in constant mesh, and by the use of this duplex clutch the ordinary engine clutch and pedal clutch are dispensed with. The two clutches are operated by a single lever in the cab, and cannot possibly be both in engagement at the same time. If one clutch is in action the other is loose, and change of speed can be made without shock, as the drive being frictional the clutch will slip if too highly loaded by a sudden change over. The engine is mounted near the trailing end of the frame. It is a four-cylinder petrol engine having a bore of 4 in. and a stroke of 5 in. It develops 25 to 30 brake horse-power at full speed, the consumption being about ¾ pint of petrol per brake horse-power hour. Sections through the cylinders are shown in Figs. 51 and 52. The cylinders are cast in pairs. The water jacket space is liberal, and large openings are provided giving access to it for cleaning purposes when required. As best seen in Fig. 52, the cylinder cover and water jacket cover are both secured by a single central bolt. The camshaft is driven by 2 to 1 reduction gear, and, as shown in Fig. 53, is carried at each end in a gunmetal bush

NARROW GAUGE PETROL LOCOMOTIVE AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE DREWRY CAR COMPANY, LIMITED, ENGINEERS, LONDON.

FIG. 48.

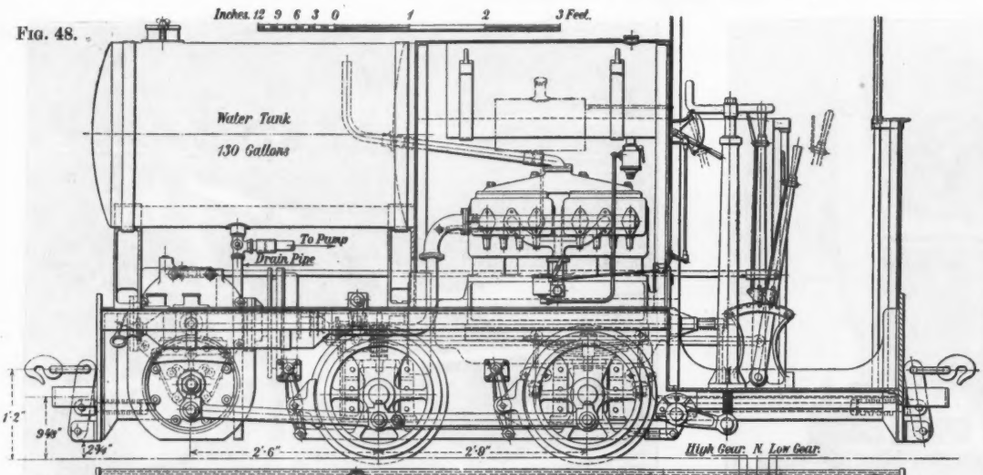


FIG. 50.

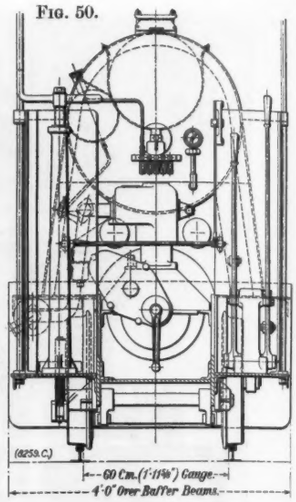


FIG. 49.

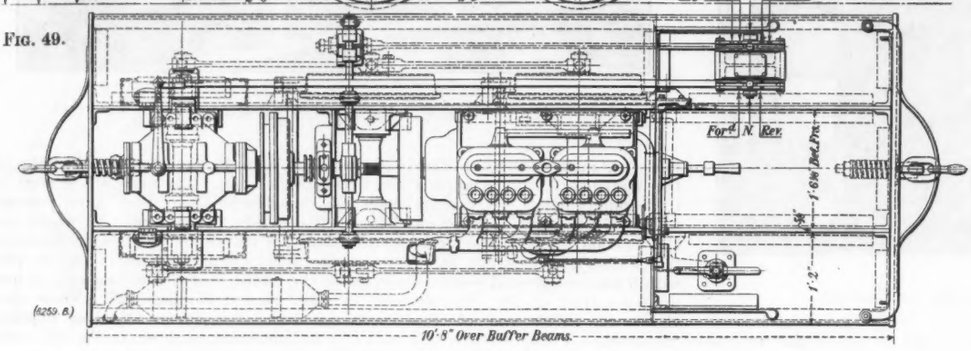


FIG. 53.

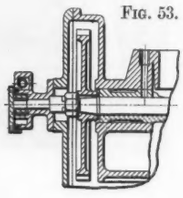


FIG. 51.

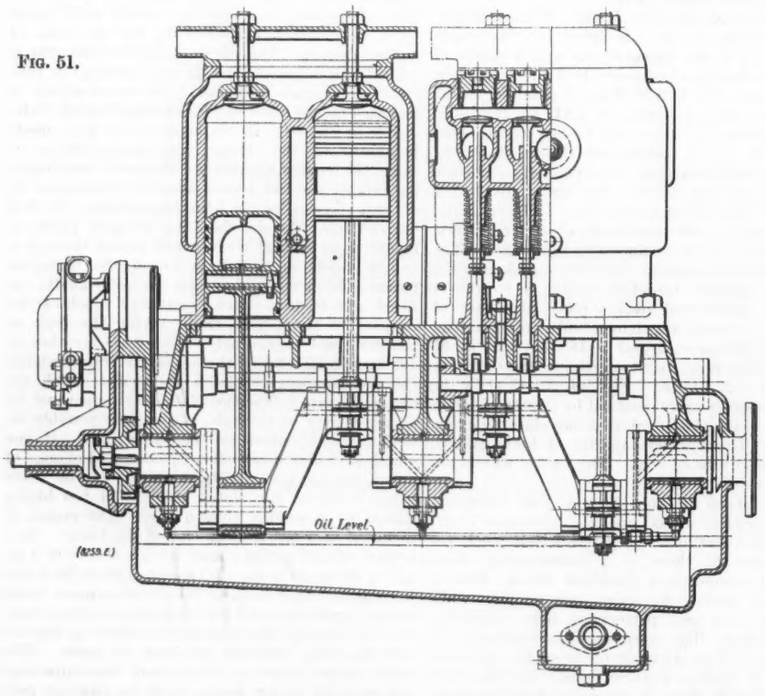
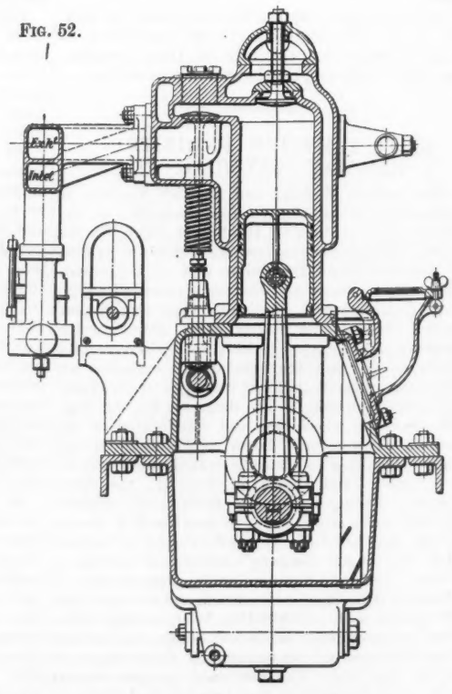


FIG. 52.



locked in place by a clamping screw. Both admission and exhaust valves are positively operated. They are of nickel steel and the tappets are adjustable. Ignition is by high-tension magneto mounted as indicated in Fig. 52. The crankcase is of cast iron, and is closed at the bottom with a cast-iron well in which the spent oil collects and whence it is drawn up and passed through a strainer which is arranged in a pocket cast below the oil well as indicated in Figs. 51 and 52.

We reproduce in Fig. 56, page 672, a photograph of the locomotive ready for the road, which, it will be noted, has a distinct resemblance in general outline to the ordinary steam locomotive. This is largely due to the water tank which is a horizontal cylinder capable of holding 130 gallons. The engine occupies the part usually assigned to the fire-box, and is easily accessible through hinged

PETROL LOCOMOTIVE; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE DREWRY CAR COMPANY, LIMITED, ENGINEERS, LONDON.

FIG. 54.

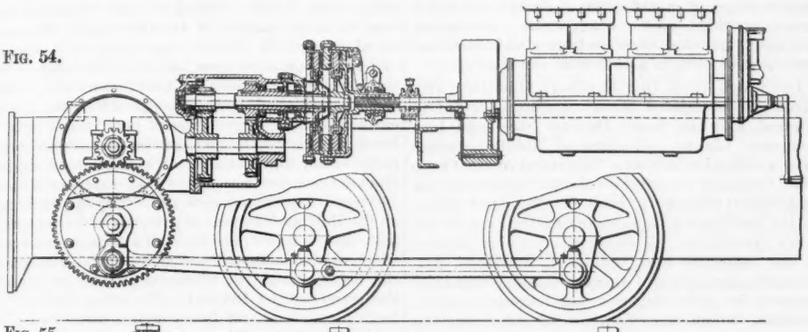
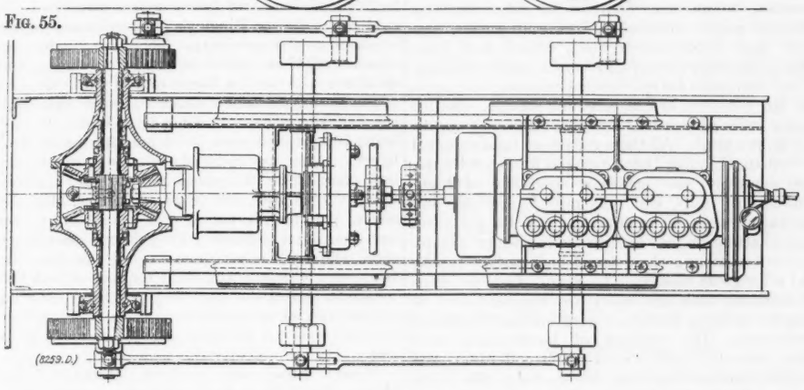


FIG. 55.



doors. The fuel tank holds 20 gallons of petrol. The total weight of the engine in running order is about 4 tons. The builders, it may be added, make engines of this type, in a range of sizes varying from 10 h.p. up to 150 h.p.

The standard Drewry car is now so well known to railway engineers all over the world that a detailed description of this exhibit is hardly necessary. These little vehicles have amply proved their serviceability, especially in such countries as India, Africa, &c., where inspection or other small parties require to travel rapidly and independently over considerable distances. The 20 h.p. car, as stated above, seats six passengers. It is fitted with a four-cylinder engine of 90 mm. bore and 130 mm. stroke and running at 1,000 r.p.m. The crankshaft is of forged nickel steel and is carried in three phosphor-bronze bearings. The connecting rods are of high tensile steel, of H-section, and have adjustable phosphor-bronze white-metal lined big ends and phosphor-bronze bushes at the little ends. The valves are of nickel steel and are interchangeable. The ignition is by high tension magneto. The gear-box gives three speeds forward of 7, 16 and 27 m.p.h. respectively and the same in reverse. The car can be driven from either end and can therefore travel equally well in either direction without turning. The transmission is by shaft from engine to gear-box, and from the latter to the axle by silent chain.

The wheels are 24 in. in diameter and of the Newlay forged type. Hand brakes are fitted to two wheels. Radiators are fitted at each end of the car, cooling being by rotary pump driven from the engine. The car is fitted with cushioned seats and padded reversible throw-over backs, so that passengers can always face the direction of travel. Weather boards are fitted at both ends, with glass windows, capable of being lowered, extending to the canopy. The canopy is carried by end pillars and is supported by stanchions at the seats. Side doors are fitted, and side curtains, kept rolled up under the roof when not in use, can be made to enclose the sides completely, by being clipped to fastenings at about seat level.

The Drewry light inspection "Alpha" trolley shown we illustrate in Figs. 58 and 59, page 672. The particular point about this little machine is the fact that the whole engine unit can be lifted out of the trolley as indicated in Fig. 59. Fig. 58 shows the complete machine. As all the gear is immediately below the seat, the latter has to be removed before the engine can be taken out. This is a moment's work only, as the legs of the seat fit into sockets on the frame sole bars. The whole of the engine is mounted on a trussed sub-frame fitted at the ends with vertical jaws which slip over cross bars of the main frame. The sub-frame is held down to these cross bars by locking bolts in the bottom ends of the jaws, withdrawn, for lifting out, when the lifting handles are raised. The drive is transferred from the engine by chain to a countershaft, and from the latter by spur gears to a countershaft on the main frame, whence it is taken to the front-axle by chain and sprockets. The motor is a two-cylinder Vee air-cooled engine in the example illustrated. The power of these engines may be 6 or 8 h.p., according to the preference of the purchaser, while trolleys are also fitted with single-cylinder 4-h.p. motors. The B.S.A. speed gear give three changes. The complete trolley weighs about 5½ cwt., while the engine and transmission unit weighs 3 cwts. Carburettor controls, change speed lever, &c., are all close to the seat in front. District and other engineers who have to travel long distances will appreciate the valuable features of this trolley. The engine unit is so quickly removable that the trolley can be safely used by two men in many circumstances in which the ordinary motor trolley is restricted to "line clear" working. The removal of the power unit and then the "cutting" of the trolley itself is a matter of practically no loss of time owing to the small weight of the two parts. This, as many engineers well know, makes it possible to get to particular pieces of work, and away again without being delayed by, or interfering with, ordinary traffic, and avoids having to fix upon some particularly suitable interval between trains. Again, when inspection is necessary at the end of a district, and it is necessary to cover part of the distance by train, the removal of the power unit makes it possible to ship the trolley in a much smaller space than when it is a fixed part of the vehicle. The engine can be stood on the van or truck floor and the trolley itself stood upright, while in this way it is possible to get the trolley through comparatively small van or truck door openings without upsetting the engine and petrol tank. With such advantages this type of trolley should prove a very popular machine.

Although long well known as builders of main line locomotives, Messrs. R. & W. Hawthorn, Leslie and Co., Limited, of Newcastle-upon-Tyne, have been content to illustrate this branch of their work by means of models only. They have, however, an exhibit of considerable interest as regards the smaller ranges of locomotives, in the form of an electric battery-shunting locomotive, and a combined shunting crane locomotive. The latter is an example of an appliance which has formed one of the leading specialities of the firm for many years. The engine consists of a 4-wheel outside cylinder side-tank locomotive for standard gauge. The cylinders are 14 in. by 20 in. and the four coupled wheels are 3 ft. 4 in. in diameter, the wheel base being 6 ft. 6 in. in length. The crane is mounted over the boiler. No blocks and winding tackle are provided, lifting being arranged for by three hooks at fixed radii of 12 ft., 16 ft. and 22 ft., together with the luffing of the jib. The long jib is held by and pivoted to two strong upright links in turn pivoted to lugs on a turntable. The jib is continued beyond the links and the tail is connected to the piston of a steam cylinder whose vertical axis coincides with that of the turntable. Steam is admitted to both sides of the piston in this cylinder, and the jib is operated by regulating the steam on the underside, exhausting to lift and admitting to lower. A counterbalance is carried by an extension built out from the turntable, while on the base is fitted a small slewing engine worked by steam and driving a pinion in gear with a large spur ring on the turntable itself. The crane-engine exhibited is capable of lifting 3½ tons at a radius of 22 ft., 5 tons at 16 ft., and 7 tons at 12 ft. These loads can be lifted and moved without the use of rail clips. Crane locomotives of this type have now been in use so long that little need be said as regards their utility.

Of rather more novelty the other locomotive exhibit of Messrs. Hawthorn, Leslie will doubtless attract a considerable amount of attention. The electric battery-shunting engine shown and illustrated in Fig. 57, page 672, is also for the 4-ft. 8½-in. gauge; it has four coupled wheels 3 ft. 3 in. in diameter and a wheel base of 7 ft., and weighs in working order 15·6 tons. The driving motor fitted is only 50 b.h.p. on one-hour rating, and the machine has a tractive force of 5,545 lbs. at 2·875 m.p.h. The engine is therefore not a very powerful example of the system, but is of a size to do much useful work in works and yards. The system on which the locomotive is designed is known as the Paragon "B and B" system, of Captain W. P. Durtnall. In this system the battery supplies current at constant voltage to the motor of an "electro-kinetic transformer," the generator of which supplies variable voltage current to the main driving motor, according to the field conditions regulated by an 18-step controller. This gives the locomotive 18 efficient speeds. The driving motor is mounted on the main frame of the locomotive, one axle being driven by means of worm and spur gearing. The whole weight is utilised for adhesion by the use of outside coupling rods. The battery consists of 96 D.P. "Kathanode" cells, T.R. 21 plate type, having a 240-ampere-hour capacity at the 5-hour rate of discharge. These are manufactured by the "D.P." Battery Company, Limited, of Bakewell, Derbyshire. The system is, however, of course, not limited to use with a particular type of cell, and these can be arranged to suit the purchaser.

The driver's cab is situated in the centre of the locomotive and contains the "electro-kinetic" transformer, the eighteen-speed controller, reversing lever, hand brake, and instrument panel. Reversing is accomplished by changing over the leads to the main motor. The reversing lever has three positions, one for forward, one for reverse and a central position for charging. When in the latter position the main motor is cut out and the charging leads are coupled to the generator unit of the electro-kinetic transformer, the controller being adjusted to suit the voltage of the supply. The generator

under these conditions acts as a motor, and the motor of the transformer as a generator, the latter supplying current at 192 volts to the battery. By means of the field adjustment possible with the controller direct-current supply with any voltage between 80 and 500 can be used for charging. Slight alterations make it possible to charge from alternating-current supply. The locomotive makes use of regenerative braking, and the cells therefore benefit by a number of boosting charges during a day's work. This naturally prolongs the time between charging and tends to increase the life of the battery. It is claimed that the "B. and B" system in certain classes of service makes it possible to eliminate 30 per cent. to 40 per cent. of the cell capacity as compared with series-parallel working, thus reducing charging costs; but in first cost the substitution of the so-called electro-kinetic transformer would tend to off-set capital saving.

METALLURGY AT THE BRITISH EMPIRE EXHIBITION.—II.

WE continue our review of the metallurgical exhibits by first noticing those shown by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, and by their associated companies. Other important sections of their work will be referred to in subsequent articles dealing with specific subjects. Taking in the first place the display made by the Elswick Works, Newcastle-on-Tyne, the drop forgings will be found to cover a wide range and to include stampings used in most branches of modern engineering. The samples shown are made in dies with drop hammers of the smallest size up to 6 tons in weight; they include minute crankshafts for pneumatic drills, crankshafts for motor cars and other mechanical parts, of different alloy steels, one alloy being the "Vibrac" steel, of very exceptional quality, possessing, among other qualities, the useful property of being free from temper-brittleness. Examples of practically all component parts of motor cars are on the stand, including front axles, a front hub, a connecting rod, a steering lever, &c. Component parts used in the manufacture of artificial limbs, combining strength with lightness will be found also of great interest. There are, further, items used in the manufacture of ordnance, gun carriages, gun mounting, which combine adequate wearing with high mechanical properties.

The display made by the Openshaw Works, Manchester, covers steel of all grades manufactured by them. The tool steel exhibit includes a show case containing the materials from which the steels are made, with progressive samples of ingots, bar and tempered fractures of tool steels, both carbon and special alloy steels, for high speeds and heavy duties on the hardest machining work. Finished tools are also exhibited. The production of the acid furnace department is illustrated by a cross-section of a 120-ton octagonal ingot, a 32-in. round ingot, a longitudinal section of a round ingot, and a group of smaller ingots, showing the different types of ingots produced and used for forgings by the other departments. Among the steel forgings are a turbine rotor, weighing 12 tons, a large steel binding ring and a turbine disc. The last two items are made of "Vibrac" steel, which has a tensile strength of over 100 tons per square inch, with an elongation of 10·5 per cent. and a reduction of area of 35 per cent., the impact figure being 12 ft.-lb. A lower tensile figure of 60 tons corresponds with 19·5 per cent. elongation, 58 per cent. reduction of area and 66 impact. The wide range of usefulness for this steel is also illustrated by a centre for a large inserted-tooth cutter, standard railway couplings tested to destruction, and gas bottles of only half the normal weight. Examples of torsion tests of "Vibrac" steel are shown, whilst the core trepanned from the centre of a 27-ft. forging gives evidence of the uniform quality of the metal. Several articles, including cutlery, a fan, &c., are made of the firm's stainless and rustless steel. The foundry work is represented by only a few iron and steel castings. The exhibits finally include a dilatometer, a modern photo-micrographic camera, a hand-operated torsion testing machine, and an Izod impact testing machine.

The exhibits of the firms associated with Messrs. Armstrong, Whitworth are most varied and include a piece of cannel coal weighing about 4·5 tons; coke oven by-products; steel rails and sections, bars; wire products; steel ropes; corrugated galvanised sheets; specimens illustrating the various stages of manufacture of electric detonator fuses; cartridge cases; brass sheets; aluminium castings; extruded brass sections; and numerous specimens of work in non-ferrous metal alloys.

The Cargo Fleet Iron Company, Limited, with whom are associated Messrs. Cochrane and Co., Limited, and the South Durham Steel and Iron Company, Limited—all three of Middlesbrough—have a collective exhibit. The stand of the Cargo Fleet Company consists of columns supporting the longitudinal framework, made of rolled-steel piling, on the well-known Lackawanna system, one of the firm's specialities. A show-case contains samples of raw materials, coal, iron-stone, limestone, &c., from the properties of the associated companies; by-products including basic slag, refined tar, pitch, benzoles, toluol, &c. Samples of rolled sections comprise angles, channels, joists, bulb angles, tees rivet bars, ferro-concrete steel, rounds and flats. Heavy steel rails for main lines are another speciality of the firm; rolls for bull-headed rails weighing up to 100 lb. per yard are in constant service, also for flange rails of sections varying from 40 lb. to 112 lb. per yard. All these rails have been supplied to British, Colonial, Dominion, and foreign railways. The company also makes a speciality of high-conductivity rails, and rolls rails for colliery and plantation work in weights up to 35 lb. per yard. Special attention may be directed to the firm's tramway-rail sections; these are of high-carbon quality and offer great resistance to wear. The specimens of tramway rails displayed are representative of supplies to many British corporations and to several Dominions. The exhibits of Lackawanna steel piling show the facility with which cofferdams and similar constructions can be erected; the piling can be left standing to form a permanent wall when covered with concrete to prevent corrosion.

The display made by Messrs. Cochrane and Co., Limited, includes cast-iron pipes, mild steel and centrifugally spun concrete pipes, cast-iron tunnel rings, railway chairs, axle boxes, and other castings; also coal, coke and ironstone specimens, a series of coke oven by-products. Their steel pipes, concrete lined, are specially interesting exhibits, as also are their cast-iron and steel pipes which are protected from corrosion by a hydro-carbon composition which is applied centrifugally to the pipes. This treatment gives the pipes a highly polished surface, reducing friction losses to a minimum; the lining is entirely impervious to water, and tests have shown it to be impervious also to a large number of acids, caustic solutions, and other highly corrosive liquors. Another speciality of the firm is the manufacture of 3-in. to 60-in. concrete pipes, both non-reinforced and reinforced, by the Vianini mechanical process, for which Messrs. Cochrane are the concessionaires. The cast-iron tunnel rings exhibited are specimens of the contract for a total of 60,000 tons which the firm have on hand for the Clapham Common to Morden extension of the City and South London Railway.

The central exhibit of the South Durham Steel and Iron Company, Limited, is a model of a new Talbot tilting basic-steel furnace of 500 tons capacity, showing the chequer chambers, gas and air flues, and waste-gas flues; the tilting arrangements are similar to those fitted on other Talbot furnaces except in the case of the rockers, which for the new 500-ton furnace operate on roller bearings. The stand is built solely of the company's own products; the upright girders are of sectional steel of square shape, the space between the angles being filled with expanded steel, and the floor covering is of steel chequered plates. Among the specialities of the company are steel ship and boiler plates, and plates for all constructional purposes, also steel railway sleepers. Processes of manufacture at the works of the three companies are shown by a cinema on the South Durham Company's stand.

Representative exhibits of iron, from the brand "Netherton Crown" for ordinary smith work, to "Netherton Treble Best," and "Best Best Loco.," for first-class engineering work requiring high test results, also "Netherton Best Yorkshire," for railway draw-gear, mining chains, best boiler rivets, &c., and "Lion Brand" iron, are shown by Messrs. N. Hingley and Sons, Limited, Netherton Iron Works, Dudley. They display a specimen of the firm's best quality Yorkshire iron, depicting the very excellent quality of fracture which this material gives, fully 100 per cent. being of a fibrous character. Another iron bar, after threading over the whole length, is seen, bent cold round a bar of the same diameter and showing no sign of fracture. Show cases contain a large series of hot "ram's horn" bends, double bends made in the cold, and a large range of bar iron sections. A knot made of a 5-in. diameter iron bar was pulled cold under a stress of 140 tons. Several anchors are displayed, one being on the Hall latest improved pattern; this does away with the oblique pins in Hall's patent anchor—which were sometimes objected to—and also increases the holding angle to 42 degrees. The anchor on the stand weighs 165 cwt. The other anchors of large dimensions and heavy weight exhibited give evidence of Messrs. Hingley's production capabilities in regard to this speciality. There are, further, two samples of 3¾-in. and 4-in. stud link chains, both of which withstood a stress of 350 tons, the limit of the testing machine; also a 3-in. open link chain, the breaking stress of which is 258 tons 16 cwt., being 166 per cent. over the Admiralty tensile stress figure. Other specimens of the same nature include link chains for all engineering purposes. Messrs. Hingley own iron ore mines, collieries, blast furnaces, puddling furnaces, and manufacture their iron from start to finish. They do not manufacture steel, and have never done so, but purchase steel from outside sources and make forgings of both their own iron and of the steel they purchase, according to any special requirements; their stand includes a forged steel roll and a forged steel hammer piston rod.

Messrs. Spear and Jackson, Limited, Ætna Works, Sheffield, a firm which was established in 1774, have an attractive display of saws and other tools, one remarkable specimen being a band saw 60 ft. long by 12 in. wide, for wood, probably one of the largest saws of the kind in the world. Their circular saws range from 3 in. to 6 ft. in diameter, and they are, we believe, the only firm in this country to manufacture circular saws having inserted teeth for cutting wood. The teeth are easily inserted and removed by hand. Their circular saws for cutting steel rails, girders, bars and thick plates, have high-speed steel inserted teeth, with flat and round noses alternating for dividing the shaving. There are three cross-cut saws 12 ft. in length each. A circular saw is shown in motion, the teeth of which are in groups, the saw being hollow ground from collar to rim; a perfectly smooth cut is made through wood, the cut surfaces requiring no further planing or sand-papering. This constitutes a most useful tool for cabinet makers. Three hand saws are exhibited which were made by the firm prior to 1820 and are still in good working condition. Present-day hand saws of vanadium steel are also exhibited, one of which is shown, the end of the blade being twisted round through the handle; the saws, after remaining in this position for 12 months, are stated to return afterwards perfectly flat. Messrs. Spear and Jackson have also made a speciality of all kinds of hand tools of steel; one of these is a specimen of their "Never-bend" hand shovel which has dealt with 15,000 tons of coal in their own boiler-house and is still capable of much work. New shovels and forks made of the same quality steel are exhibited, and the manner of testing them is illustrated on the stand with the actual specimens. "Long life" picks for navvies and colliers, hatchets, choppers, and other cutting tools are tested on iron bars without damage to the cutting edge. Other cutting tools are knives, slicers, &c., for all industrial purposes; they include cork and rubber cutters. The firm's new patent tough-centre, hollow drill steel has the inner core round the hole down the centre of the rod of mild steel, which prevents the drill from cracking from the face longitudinally. This new steel is specially suited to the work in the South African gold mines. All the steel used by the firm is made at their works in electric steel furnaces.

The Institute of Metals has had only one paper

dealing directly with Monel metal, namely, a paper by Mr. J. Arnott, read on February 17, 1920, before its Scottish local section. A paper on practically similar lines was read by the same author on April 13, 1923, at a joint meeting of the Sheffield local section with other technical bodies.* Several other papers have dealt with this metal, but indirectly only. This comparatively very scanty reference to the metal may be taken in some measure as affording a conclusive proof of its extremely high value for a multitude of engineering and other purposes; had Monel metal been subject to corrosion, to marked failure under given conditions, to the numerous ills to which other non-ferrous metals and alloys are heir to, we venture to suggest that the proceedings of the Institute would have contained a large number of papers, together with heavy discussions thereon, describing the occurrences and proposing the best means for counteracting them. A few of the characteristic physical features of the metal are given in the paper we refer to above; but much more convincing probably is the Monel metal stand of Messrs. G. & J. Wier, Cathcart, Glasgow, at the Exhibition, where a profusion of specimens of all kinds is shown. The metal is obtained from a natural ore mined in Canada, and contains 67 per cent. of nickel, 28 per cent. of copper, 2 per cent. of iron, small amounts of manganese, silicon, cobalt of sulphur, and no tin, zinc or antimony.

Monel metal is received by Messrs. Weir, the sole concessionaires, in ingot, rod or sheet form and is worked up by them. The average tensile strength per square inch for Monel metal at ordinary temperatures is quoted at 42 tons, as against 31 tons for mild steel, and at a temperature of 750 deg. F. the respective average figures are given as 35 tons and 27 tons. Turbine blades made of Monel metal are immune to corrosion and erosion; the same can be said for valves and other turbine and engine parts which work in superheated steam. The metal, further, resists a very wide range of acids and alkalies, and is more suitable than any other for pump liners, rods, glands, &c., in plants which have to deal with waters saturated with chemical works' refuse. In the chemical works themselves, in dye works, textile factories, gas works, glue works, soap works, sugar works, and others, the metal is gradually replacing other alloys. It has been found to give excellent results in the welding of cast iron. The Monel metal stand contains illustrations of the above applications, together with many others, including special springs for a number of engineering purposes, needle valves for Ford cars, strainers of Monel metal wire netting for Rolls-Royce cars, fine mosquito netting, surgical instruments, iris diaphragm leaves for photographic lenses $\frac{3}{1,000}$ in. thick. Many of the specimens shown have seen long service under very severe conditions. These few remarks on a most comprehensive display will give an idea of the numerous applications to which Monel metal has satisfactorily been put. For many purposes it may with advantage be selected instead of another non-ferrous metal or steel. The same stand contains the Hurrel Homogeniser, manufactured by the Sun Lane Engineering Works, Blackheath, S.E. 3, a high-speed mill for emulsification and for the disintegration of solids.

LETTERS TO THE EDITOR.

"THE TRANSVERTER."

To the Editor of Engineering.

SIR,—I hardly think that your correspondent Mr. A. M. Taylor has done justice to the Highfield transverter in his letter published in your issue of May 16. To argue that because the first transverter set ever built has only a capacity of 2,000 kw. it would therefore require 13 transverters to transmit 25,000 kw. is as unjustifiable as it would have been in 1884 to say that because the first Parsons turbine developed only 10 h.p. hundreds of turbines would be required to drive a ship across the Atlantic.

Mr. Taylor then states that "the first thing that strikes one" is the loss of efficiency due to the conversion and re-conversion of the current, although why this should be substantially greater than the loss in the transformation and re-transformation necessary with all E.H.T. transmissions I fail to see. The first thing that struck me about the Calverley-Highfield system was something quite different. It was that all overhead transmission circuits would be reduced from three lines to two, with a corresponding reduction of 33 per cent. in the number of insulators required and a material lightening of the mechanical stresses in the poles or towers. The next thing was that transmission by direct-current at 100,000 volts is no more severe on the insulation of the line than alternating-current transmission at, say, 70,000 volts, quite apart from questions of surges, &c., which give so much trouble on E.H.T. systems.

Alternating current transmission has certainly reached a very advanced state of development, but so had the reciprocating steam engine when the turbine came along. The analogy may be closer than Mr. Taylor would admit. Many engineers are of the opinion that alternating-current transmission is near its limits, and that future progress must be along some such lines as indicated by Messrs. Highfield and Calverley. As long ago as 1919 Dr. Dolivo-Dobrowolsky wrote in *The Electrician*, "The author is of opinion that a new struggle will arise between alternate and direct current [for power transmission], in which the latter will emerge victorious," and he gave the most cogent reasons, for his views, and they are as true to-day as then.

With regard to the question of cost, upon which Mr. Taylor lays so much stress, I think it is hardly likely that the English Electric Company would have gone to the expense of developing the transverter unless they had abundantly satisfied themselves that it was likely to be as successful commercially as it has proved to be technically. I hope it will, for it does one good to see a British firm designing something for itself, instead of taking up, as so many do, second-rate Continental designs.

Yours faithfully,
"CHARTERED."

London, May 20, 1924.

PRIVATE ENGINEERING STUDENTS.

To the Editor of Engineering.

SIR,—I have noted occasional remarks in your journal on the education of engineers. These contributions, however, have generally been those of university graduates or students, and I should like to offer a few remarks from another standpoint; that of a private student. In the notes of a new book the reviewer has seen fit on two occasions to make the following statements. Of a certain book he said, in effect, "this will be found suitable for certain students, down to the student of a correspondence college at the other end of the scale," and again on page 649 of the present volume he says that a book (which by the way is only "quasi-scientific") "resembles a class of literature for the information of men of the garage mechanic or correspondence course student types."

Now I think that it can be fairly claimed that a student of a correspondence course and a student who extracts his information from books (without any tutor) are in an identical situation and, therefore, the above remarks are applicable to both. To my mind the off-hand depreciation, as given above, of this type of man is more than a little deplorable.

The apprentice or workman who, after his work at the factory, expends his time in studying the theory of his craft is worthy of praise, and I can positively state that it is only the very best literature that is suitable for his information. The type of man referred to, however, is generally able to appreciate that which is good: perhaps unlike his more fortunate university brothers he has no time for the assimilation of a mass of data of the utility of which the former can have no conception.

Yours faithfully,
I. H. HUNTER.

10, Troquere Villas, Ormskirk.
May 19, 1924.

[It was not our intention to publish anything in disparagement of private engineering students, some of whom are undoubtedly of exceptional ability. Many correspondence courses are moreover remarkably well arranged. We would refer our correspondent to the first "Note on New Books" on page 770 of our issue of Dec. 21, 1923.—ED. E.]

THE SOCIETY OF ENGINEERS (INCORPORATED).—This society is convening two conferences of the institutions associated with it, which are to be held on Friday, June 6, and Monday, September 15. They will be held from 10.30 a.m. to 1 p.m. During the mornings short papers on engineering subjects will be read and discussed. Members of other societies will be supplied with tickets. Application should be made to the Secretary of the Society, 17, Victoria Street, Westminster, S.W. 1.

INDUSTRIAL NOTES.

The Ministry of Labour state that there was a further improvement in employment in April. Among workpeople insured under the Unemployment Insurance Acts in Great Britain and Northern Ireland, the percentage unemployed on April 28, was 9·7, compared with 9·9 on March 24, and with 11·4 in April, 1923. Among members of Trade Unions from which returns were received the percentage was 7·5 at the end of April, compared with 7·8 at the end of March. The total number of workpeople registered on April, 28, at Employment Exchanges in Great Britain and Northern Ireland as applicants for employment was approximately 1,052,000, of whom 790,000 were men and 194,000 were women, the remainder being boys and girls; on March 31 last, the total was 1,057,000, of whom 791,000 were men and 204,000 were women. Employment was good in the coal mining, tinplate, steel sheet, carpet, jute and coachbuilding industries, and among skilled workmen in the building trades; it was fairly good in the wool textile industry, with millsawyers and brickmakers, and in certain sections of the metal trades; and fair with various other trades. In some of the other large industries, however, including iron and steel manufacture, engineering, shipbuilding, and pottery manufacture, it continued slack.

The gradual upward movement in wages, which has been in progress since the beginning of the year, continued in April. In the industries for which statistics are available the changes in rates of wages reported during the month resulted in an aggregate increase of 26,000*l.* in the weekly full-time wages of nearly 230,000 workpeople, and in a decrease of 3,800*l.* in those of nearly 90,000 workpeople. Among the workpeople whose wages were increased, iron puddlers and iron and steel millmen in the Midlands obtained an advance equivalent to about 3¼ per cent on current rates, and blastfurnace workers in Cleveland, Staffordshire, Nottinghamshire, Northamptonshire, South Wales, and Scotland obtained advances varying from under ¼ per cent. on current rates in Cleveland to 1¾ per cent. in Northamptonshire. There were also increases in the rates of wages of electrical cable makers, brass workers at Birmingham, tramway workers in London, cement workers, paint, colour and varnish makers, iron-stone miners in Cleveland, workpeople employed in the seed-crushing and oil-milling industry, woollen and worsted operatives in the West of England, and vehicle builders, house painters and electricians in Scotland. The decreases reported were mainly due to the operation of sliding scale agreements, under which wages fluctuate in accordance with variations in the official cost-of-living index figures. The principal group of workpeople whose wages were so reduced were operatives in the textile bleaching, dyeing, printing, &c., trades in Yorkshire, Lancashire and Cheshire and Scotland. During the first four months of 1924 the changes in rates of wages reported to the Labour Department have resulted in net increases amounting to over 230,000*l.* in the weekly full-time wages of 1,800,000 workpeople and in net reductions of 37,500*l.* in the weekly wages of nearly 680,000 workpeople. In the corresponding period of 1923 there were net reductions amounting to 250,000*l.* in the weekly full-time wages of over 2,100,000 workpeople and net increases of nearly 23,000*l.* in the weekly wages of nearly 190,000 workpeople.

On May 1, the average level of retail prices of the commodities taken into account in the statistics prepared by the Ministry of Labour, was approximately 71 per cent. above that of July, 1914, as compared with 73 per cent. a month ago and 70 per cent. a year ago.

The number of trade disputes involving stoppages of work reported to the Department as beginning in April was 46. In addition, 21 disputes which began before April were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in April was approximately 51,000, as compared with 76,000 in the previous month; the estimated aggregate duration of all disputes during April was about 471,000 working days, as compared with 730,000 days in March. The principal disputes during April were those involving shipyard workers. During the first four months of 1924 the stoppages of work owing to trade disputes reported to the Department have involved approximately 326,000 workpeople, as compared with 187,000 workpeople involved in disputes in the first four months of last year. The aggregate duration of the stoppages in January to April, 1924, has been over 2,500,000 working days, as compared with about 2,300,000 in the corresponding period of 1923.

The Federation of British Industries states that it has been endeavouring for a considerable time to

* See ENGINEERING, vol. cxv., page 495.

persuade successive Governments to pass a measure which would permit orders to be made for the compulsory marking with the country of origin of foreign goods, imported into Great Britain, the object being to enable the British public to distinguish goods of foreign manufacture, and to give them the opportunity of buying British articles if they prefer to do so, as the Federation has reason to believe is generally the case. After the General Election, the matter was again put before the Board of Trade who replied that they were not satisfied, among other points, that there would be sufficient unanimity to enable a Bill to pass into law as an agreed measure. To this, the Federation replied to the Board of Trade, setting out a number of facts, and stating it believed that the British public, speaking generally, preferred British goods to foreign, and desired to have the opportunity of distinguishing between the two. It, therefore, felt convinced that the introduction of the necessary legislation would have very beneficial effects upon production and employment in this country, which it knew to be a matter of peculiar concern to H.M. Government at the present time.

A Bill for the Nationalisation of Mines and Minerals came up for second reading in the House of Commons last Friday. It was brought forward as a private member's measure, but had the whole-hearted approval of Government, as was stated by Mr. Shinwell, the Minister for Mines. The Bill was rejected by 264 votes to 168.

The Conferences, which have been held on the subject of the dispute on wages in the building trade, have led to the formulation of new terms by the employers as a basis of settlement. The terms cover the adjustment of wages, the effect of the cost of living index figure, the position of the London operatives, and the question of working hours in relation to the state of employment. A ballot on the terms is to be taken, the vote being returnable at the end of the present month.

The Court of Inquiry into the Leith coal tippers and trimmers' dispute referred to on page 636 *ante*, was held on Monday last at Edinburgh, Lord Anderson presiding. Mr. Robert Williams, acting on behalf of the men, stated how the trouble arose; the difficulty, he said, concerned the charge hands, three of the twelve appointed by the men at Leith not being approved by the employers. No explanations being vouchsafed, there was a strike, which lasted nine weeks. One hundred strike workers had been employed, 21 of them having been guaranteed permanent employment. To reach a settlement the Trimmers' Union agreed to assist in compensating for the loss suffered by the workmen who had been disloyal to them, but that offer must now be withdrawn. The coal trimmers had resolved not to work alongside these 21 men. Mr. James Currie, Leith, speaking on behalf of the employers, maintained that the strike did not take place because of the refusal to recognise the charge hands, but because the men declined to take instructions except through their own supervisor. The men put forth no demands, but simply walked away. The Court, it was announced, would report to the Ministry of Labour as speedily as possible.

Following the findings of the Court of Inquiry in regard to wages in the coal mining industry reported in our issue of last week, negotiations took place between the Council of the Mining Association and representatives of the Miners' Federation, when new proposals by the Mining Association were put forward and agreed upon. As will be seen, they represent a further sacrifice on the part of the coalowners, and the Miners' Federation will recommend their acceptance at a delegate conference to be held in London on the 29th inst. The new proposals read:—

1. Standard profits shall consist of a sum equal to 15 per cent. of standard wages, instead of 17 per cent. as at present.

2. The surplus remaining after the deduction from proceeds of cost of standard wages, costs other than wages, and standard profits, shall be divided between wages and profits in the proportions of 88 per cent. to wages, and 12 per cent. to profits, instead of the present proportions of 83 per cent. to wages, and 17 per cent. to profits. The general minimum percentage on standard wages shall be increased from 20 to 33⅓.

3. In no district shall the wages of any adult able-bodied wage workman fall below a figure 40 per cent. above the standard wages—as defined in Clause 7 of the Wages Agreement dated July 1, 1921—of the lowest paid class of day wage workman in the district. For this purpose the word "district" means each district within an area where the area comprises more than one district, and not the area as a whole.

4. In addition to the provision made in paragraph 3 above for improving the position of the lower-paid classes of day wage workmen, subsistence wages shall be paid in those areas in which they have been, or may in future be, fixed by the District Board, as provided by Clause 5 of the existing agreement, and allowances already fixed by the District Boards shall be increased by one-eighth.

5. There shall be effective recoupment of deficiencies below standard profits, but only one-third of any future surplus available for this purpose in any one ascertainment shall be so applied, and the remaining two-thirds shall be divided between wages and profits in the agreed proportions, any balance of the deficiency being again carried forward.

6. The owners undertake that they will deal in the district with cases of anomalies in the wages of men at or near the level to which the lowest paid class of workmen will be brought by their proposals.

THE OPTICAL SOCIETY.

A MEETING of the Optical Society was held at the Imperial College of Science on Thursday, May 8.

The first paper presented and discussed was on "*The Preparation of Coppered Glass Mirrors*" by E. A. H. French. An earlier research on this subject, he stated, was conducted by Chattaway in 1907, using phenylhydrazine as a reducing agent, but on his findings it was not possible to obtain a coherent copper film on plate glass surfaces. The author suggested that this was probably due to the formation of tarry by-products, which appeared inevitably to result when such a reducing agent was used. A considerable amount of research was conducted at the War Department Searchlight Experimental Establishment, with the object of eliminating this drawback, as well as temperature difficulties insuperable from the use of phenylhydrazine. The paper presented in detail the results of a few of the principal experiments which were conducted during the necessary research, and fully defined a new method which, by the use of hydrazine sulphate, enabled a satisfactory coherent and lasting film to be deposited on plate glass surfaces, at a comparatively low temperature. As it appeared that the cleaning of the glass surface was peculiarly important to the film deposited thereon, a short statement was made as to the cleaning method which was found to be conducive to a satisfactory copper film.

The second paper read was on "*The Taylor-Hobson F/2 Anastigmat*" and was by H. W. Lee, B.A. An analysis of the aberrations of an anastigmat lens having an aperture of F/2 was given, and comparisons made with existing large aperture lenses. Some examples of the performance of the actual lens as manufactured were added. The lens had proved useful in theatrical photography, since by its use the actual performance on the stage could be photographed with the ordinary stage lighting. It also permitted of kinema photographs being taken with less intensely actinic light than was at present used in kinematograph studios. In astronomy the new lens should prove useful. Its large angular field, combined with its large linear aperture, made it possible to plot star fields very rapidly. It should also be possible to photograph meteors, a thing which had not yet been accomplished with any other lens. The illumination in the meteor image had been shown to depend on the aperture ratio and the quality of definition of the lens, and of course the large field was a necessity. There were other astronomical uses to which the lens would doubtless be put.

"*A Reference System for Primary Aberrations*" by T. Smith, M.A., F.Inst.P., was the title of the third paper. The author said it was proposed to employ as a complete reference system for primary aberrations, the state of correction of spherical aberration along the whole axis. Such a system was advantageous, since it involved no arbitrary choice of object and stop positions.

THE LATE MR. W. H. COOK.—We note, with regret, the death of Mr. William Hall Cook, well-known as a textile machinery engineer, which occurred at his residence, 434, Wellington-road, Heaton Chapel, on May 15. Mr. Cook served his apprenticeship with Messrs. Taylor Lang and Co., of Stalybridge, and at the same time took full advantage of the facilities afforded for technical education in that district, with the result that he received many of the premier awards in the City and Guilds examinations. After two years' service with Messrs. J. Carter and Son, of Stalybridge, Mr. Cook returned to Messrs. Taylor, Lang and Co., and was employed from 1884 to 1887 in the tool department. He then undertook the management of Messrs. Robert Buckley and Co., of Stalybridge, where he remained until 1889, when he joined Messrs. Brooks and Doxey as assistant manager. He was promoted to the managership in 1898, and held the post for six years, after which he started in practice as a textile machinery adviser. Mr. Cook was elected a member of the Institution of Mechanical Engineers in 1905, and he was a Member of Council of the Manchester Association of Engineers.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—The amount of coal that has passed through Hull for export, according to the official returns for April, shows a diminution of over a quarter of a million tons as compared with the corresponding period last year, and since the beginning of the year overseas trade has shown a falling off of over 700,000 tons in comparison with January to April, 1923. Germany, Belgium, Holland and Denmark have all been taking reduced quantities. Of the individual collieries in South Yorkshire, Denaby and Cadeby alone showed an increased output for shipment by over 9,000 tons. Brodsworth, Bullcroft, Hickleton, Ramcroft and Yorkshire Main exported 71,303 tons last month, while in April, 1923, they shipped 84,873 tons, a difference of 13,570 tons.

Iron and Steel.—The position in the steel and engineering trade of this district has undergone very little change during the past week. Continental and American competition, which showed an inclination to wane, again appears to be somewhat keener. The allocation of a contract by the Glasgow Corporation for the manufacture of tramway track to a Sheffield firm, despite the fact that their quotation was 500*l.* above that of an American concern, is attributed to considerations of quality of manufacture. In the heavy steel trade railway departments are the brightest spot, and makers of axles, tyres and other railway constructional parts are working at high capacity, but if this is to be maintained orders will have to come in more freely. Makers of automobile steel and motor-car fittings are fairly busily engaged but the future is clouded with uncertainty owing to the prospective abolition of the McKenna Duties. The demand for steel scrap has expanded considerably, and users are finding difficulty in meeting requirements, the result being that during the past week prices have increased from 87*s.* 6*d.* to 92*s.* 6*d.* per ton. In contrast, quotations for heavy wrought-iron scrap, which continues to be in moderate request, are inclined to weaken.

South Yorkshire Coal Trade.—The fall of prices from the maximum level recently reached, coupled with the seasonal change in the demand for house coal, has placed conditions on a more normal basis. Railway companies are taking big tonnages of steam hards for reserve purposes, and shipments, though reduced, still represent an active feature. Somewhat more business is passing in cobbles and nuts, while best quality slacks are a steady medium, with increased inquiries from Lancashire. Gas coke is easier, though officially rates are unaltered. Quotations: Best branch handpicked, 34*s.* to 37*s.*; Barnsley best Silkstone, 31*s.* to 32*s.* 6*d.*; Derbyshire best brights, 29*s.* to 31*s.*; Derbyshire best house, 26*s.* to 28*s.*; Derbyshire best large nuts, 24*s.* to 25*s.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 24*s.* to 25*s.* 6*d.*; Derbyshire hards, 22*s.* to 24*s.*; Rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; Nutty slacks, 12*s.* to 14*s.*; Smalls, 8*s.* to 10*s.*

THE LATE MR. JOHN MILLS.—We regret to announce the death, which took place on the 17th inst., in his eighty-first year, of Mr. John Mills, the former principal of the firm of John Mills and Co., Railway Foundry, Llanidloes, Montgomery. Mr. Mills had ceased for some time past to take an active part in the management of the firm, but continued to entertain many pleasant recollections of business associations.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—On the occasion of the celebrations in connection with the centenary of the birth of Lord Kelvin, which will be held at Glasgow University on Commemoration Day, June 25, Dr. Alexander Russell, F.R.S., the President of the Institution of Electrical Engineers, will give the Memorial Oration. Lord Kelvin was three times President of the Institution of Electrical Engineers and Dr. Russell is an old pupil of his.

A BEARDMORE SOUVENIR.—As a souvenir of the British Empire Exhibition, Messrs. William Beardmore and Co., Limited, have issued a brochure, illustrated by six reproductions from dry-point etchings by Mr. Frank H. Mason. These represent various activities in Messrs. Beardmore's works and show the forge and foundry at Parkhead, locomotive building at Dalmuir, the rolling of armour plate at Parkhead, and the basin and slips at Dalmuir. The etchings are delightful examples of the artist's work and are reproduced in a most excellent way. Brief letterpress is included in the brochure, which is appropriately bound, and the whole production forms at once a very pleasing souvenir of Messrs. Beardmore's exhibit at Wembley and an effective example of the growing link between art and commerce.

THE WILBUR WRIGHT LECTURE.—The subject of the Wilbur Wright Lecture, which is to be delivered on the 29th instant by Colonel H. T. Tizard, will be "Fuel Economy in Flight," and the lecturer will deal with the progress made and the developments to be anticipated in this direction, considering the subject from the point of view of aeroplane design, as well as from the engine standpoint. The lecture is delivered annually under the auspices of the Royal Aeronautical Society to commemorate the pioneer work of the late Wilbur Wright in the development of aeronautics. It will take place this year in the lecture hall of the Royal Society of Arts, John-street, Adelphi, W.C. 2, and will commence at 8.30 p.m. Anyone desiring to attend the lecture can obtain a ticket on application to the Secretary of the Royal Aeronautical Society, 7, Albemarle-street, London, W. 1.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig iron is very quiet, but the tone of the market is far from despondent. Output is reported fully taken up by running contracts, and stocks have been reduced to small dimensions. Producers, however, are becoming very anxious to book orders to follow on contracts fast approaching completion, and though they are reluctant to lower quotations—which they declare leave no margin of profit—customers claim they can secure price concessions for fairly good orders. No. 1 Cleveland pig is still scarce and is quoted up to 97*s.*; No. 3 g.m.b. is 91*s.* 6*d.*; No. 4 foundry, 91*s.*; and No. 4 forge, 90*s.* These quotations are f.o.b. Tees, rather lower figures being named for iron f.o.t. makers' works.

Hematite.—In the East Coast hematite branch also, sales are slow, but most makers are not badly off for work, and are markedly disinclined to lower prices. Whilst it is claimed that the figures can be shaded the recognised market quotations stand at 99*s.* for Nos. 1, 2 and 3, and 100*s.* for No. I.

Foreign Ore.—There is little or no new business passing in foreign ore, but deliveries against contracts are fairly heavy, imports to date this month exceeding 100,000 tons. Market quotations are based on best rubio at 23*s.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke is irregular in price, the tendency being downward. Sellers quote good average qualities round about 28*s.* 6*d.* delivered to local consumers, but users consider the price too high and report they can arrange for their requirements at a lower figure.

Manufactured Iron and Steel.—In one or two branches of manufactured iron and steel, fairly good inquiries are reported, but sales generally are readily arranged. Once more rather considerable quantities of cheap Continental semi-finished materials are being offered here. Among the principal market quotations are: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 10*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*; black sheets, 12*l.* 15*s.*; and galvanised corrugated sheets, 16*l.* 17*s.* 6*d.* to 17*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The position in the steel trade of Scotland continues as unsatisfactory as ever. Not only are requisitions against contract being received very slowly, but it would almost seem as if consumers were loth to pass on orders for their requirements. The demand over all is undoubtedly very poor, and this is most noticeable for ship plates. Talk of an improvement in trade in the near future is still general, but up to the present there is little sign of it developing. The inquiry is quite good, but results are not too encouraging. There is a fair amount of business being done in sectional material, but the tonnage overall is not very heavy. In the black sheet trade the conditions are a bit quieter, and although there are some fair lots still on order current bookings show a slight falling off. Most of the business being secured at present is on foreign account. Prices have not varied and the following are the market quotations:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered at Glasgow stations.

Malleable Iron Trade.—In the West of Scotland malleable iron trade the conditions are not very satisfactory, and bookings are few. In most establishments the output is much under normal, and even the current inquiry does not point to any change for the better in the meantime. The steel re-rolling departments have a fair amount of work on hand and have been fixing up more lines this week, but are still capable of a much larger turnover. Prices are unchanged with "Crown" bars called 12*l.* 10*s.* per ton, at Glasgow stations.

Scottish Pig-Iron Trade.—A quiet tone rules in the Scottish pig-iron trade, and the demands of buyers are being kept strictly within narrow limits. The inclination to place orders beyond actual requirements is entirely absent at the present time, although the inquiry from abroad shows signs of expanding. Prices keep fairly steady and are quoted as under:—Hematite 5*l.* 2*s.* 6*d.* per ton, d/d at the steelworks; foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' yards.

Shipbuilding.—An order for two oil-tankers has been placed on the Clyde by Messrs. Gow, Harrison & Co., Glasgow. These vessels will be built on the lower reaches of the river. The Pure Cane Molasses Company have contracted with the Caledon Shipbuilding and Engineering Company (Limited), Dundee, to build a twin-screw motor tanker of 10,900 tons, and a speed of 11 knots. The dimensions of the vessel will be:—Length, 475 ft.; moulded breadth, 59 ft.; and moulded depth, 33 ft. Messrs. J. G. Kincaid & Co. (Limited), Greenock, will supply Diesel engines of the Burmeister and Wain type, developing 3,800 h.p.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 17, only amounted to 908 tons. Of that total 756 tons were shipped overseas, and 152 tons went coastwise. For the corresponding week of last year the figures were 1,022 tons foreign and 278 tons coastwise, making a total shipment of 1,300 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—According to the returns of the Customs, the quantity of coal exported from the principal South Wales ports in April amounted to 2,202,515 tons, which was 57,807 tons less than in March and represented the smallest volume of trade since July, 1922, with the exception of February last, when business was affected by the partial railway strike. The value of the April shipments at 2,852,124*l.* was 6,027*l.* less than that realised for the March exports, but the yield per ton at 25*s.* 10*d.* showed an increase of 7*d.* The volume, value and f.o.b. prices per ton of coal shipped in April are shown below:—

From—	Quantity.	Value.	Price Per Ton.
	Tons.	*l.*	*s.* *d.*
Cardiff	1,379,452	1,798,630	26 1
Newport	397,964	524,869	26 5
Port Talbot	223,716	248,044	22 2
Swansea	201,383	280,581	27 11

Of the above shipments, 1,435,402 tons were large coal, which yielded 28*s.* 11*d.* per ton, or 7*d.* more than in March; 67,099 tons were through coal, which realised 21*s.* 6*d.*, or 4*d.* per ton more than in March; and 700,014 tons were small coal, for which 20*s.* per ton was obtained, the same as in March. The fluctuation which has taken place in steam coal prices so far this year is shown in the following table, giving the average f.o.b. values of steam coal shipped from Cardiff and Swansea:—

Month.	Cardiff. Small.	Through.	Large.	Swansea. Small.	Through.	Large.
	s. *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*	*s.* *d.*
January ..	19 11	22 11	27 10	17 11	20 3	28 7
February ..	20 0	24 1	27 10	16 11	20 7	26 1
March	19 7	23 0	27 11	17 0	20 6	28 1
April	19 8	23 3	28 5	17 0	21 10	27 0

Anthracite coal shipped from Swansea yielded 31*s.* 3*d.* per ton in April, that of large realising 41*s.* 4*d.*, compared with 38*s.* in March, and small 22*s.* 5*d.* against 22*s.* 3*d.*

Dock Pilots' Tariff.—A tentative agreement has been reached for a revision of the Cardiff, Penarth and Barry dock pilots' tariff for moving vessels in dock. In the old scale the rates per move were graduated from 10*s.* per move for vessels up to 250 tons net register up to 40*s.* for vessels 3,000 tons and over. In the new agreement, which operates from June 1 next, 5*s.* extra for each 500 net tons has been conceded for vessels between 3,500 tons and 5,500 tons, the rate for the latter size and above being 65*s.* per move.

MANCHESTER ASSOCIATION OF ENGINEERS.—Arrangements have been made for the members to view the extensive locomotive works of the Vulcan Foundry Company, Limited, Newton-le-Willows, on Thursday afternoon, the 29th inst.

SOCIETY OF GLASS TECHNOLOGY, SHEFFIELD.—The Council of the Society states that a party of members of the Chambre Syndicale des Maitres de Verreries de France will pay a return visit to this country during the week beginning the 25th inst. In consequence, the May meeting will be held in two sessions; the first session on Tuesday, May 27, at the University College, Gower-street, London, W.C.1, at 3 p.m.; the second session on Thursday, May 29, at the Applied Science Department, The University, St. George's-square, Sheffield, at 2.30 p.m. The first session will also be noteworthy from the fact that arrangements have been made to hold a joint meeting with the British Society of Master Glass Painters. An outline programme for the week is given. Although the visits specified have been arranged primarily for the entertainment of our French visitors, members of the Society are welcome to join in any of the arrangements. Those who propose to do so are requested to inform the secretary as early as possible, so that the latest details as to times, &c., may be forwarded to them.

THE INSTITUTION OF CIVIL ENGINEERS.—At the annual general meeting of the Institution of Civil Engineers, held on Tuesday evening, May 13, the result of the ballot for the election of officers was declared as follows:—President: Mr. Basil Mott (London); Vice-Presidents: Sir William H. Ellis (Sheffield), Mr. Frederick Palmer (London), Sir Archibald Denny (London), Mr. Ernest Frederic Crosbie Trench (London). Other Members of Council: Mr. Henry Newmarch Allott (Manchester), Mr. Albert Ashley Biggs (India), Sir John Cadman (London), Sir Dugald Clerk (London), Colonel Rookes Evelyn Bell Crompton (London), Mr. Henry Albert Cutler (Ireland), Mr. William Wylie Grierson (London), Sir Robert Abbott Hadfield (London), Sir Brodie Haldane Henderson (London), Mr. Ernest Prescot Hill (London), Mr. George William Humphreys (London), Sir Cyril Reginald Sutton Kirkpatrick (London), Sir Murdoch Macdonald (London), Mr. John MacGlashan (India), Mr. Joseph Prime Maxwell (New Zealand), Sir Henry Percy Maybury (London), Sir John Monash (Australia), Mr. George Taylor Nicholson (South Africa), John Bonsall Porter (Canada), Sir Richard Augustine Studdert Redmayne (London), Sir Hugh Reid, Bart. (Glasgow), Captain Matthew Henry Phineas Riall Sankey (London), Sir John Francis Cleverton Snell (London), Mr. William Archer Porter Tait (London), Mr. John Duncan Watson (Birmingham), Sir Alfred Fernandez Yarrow (London). This Council will take office as is usually the case on the first Tuesday in November, 1924.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—To-night at 5 p.m., at the Imperial College of Science, South Kensington, S.W. 1. "The Magnetism of Annealed Carbon Steels," by Professor S. W. J. Smith, F.R.S., A. A. Dee, B.Sc., and W. V. Mayneard, M.Sc. "Some Thermo-Magnetic Properties of Nearly Pure Iron," Part I, by W. N. Mayneard, M.Sc. Part 2 by A. A. Dee, B.Sc. "The Atomic Structure of Two Intermetallic Compounds," by E. A. Owen, D.Sc., and G. D. Preston, B.A. A demonstration of "An Anomaly in Frictional Electricity" will be given by Professor A. O. Rankine.

THE INSTITUTE OF PHYSICS.—Monday, May 26, at 4.30 p.m., at the Royal Society, Burlington House, Piccadilly, W. Annual General Meeting. Presidential Address, by Sir Charles Parsons.

THE ROYAL SOCIETY OF ARTS.—Tuesday, May 27, at 4.30 p.m., at John-street, Adelphi, W.C. 2. Dominions and Colonies Section.—"A Sketch of the Geology and Mineral Resources of Cyprus," by C. Gilbert Cullis, D.Sc., M.I.M.M. Wednesday, May 28, at 4.30 p.m. Ordinary Meeting—"The Position of the Arabs in Art and Literature," by Mrs. Arthur McGrath (Rosita Forbes).

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, May 28, at 6 p.m., at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Lecture:—"Wireless in British Military Aircraft up to August, 1914," by Major H. P. T. Lefroy.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, May 29, at 8.30 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C.2. Annual Wilbur Wright Lecture:—"Fuel Economy in Flight," by Colonel H. T. Tizard, A.F.C.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 30, at 9 p.m. The Evening Discourse will be delivered by Monsieur Lucien Bell, on "Recent Developments in High Speed Cinematography." Afternoon Lecture. Tuesday, May 27, at 5.15 p.m., Major W. S. Tucker on "Acoustical Problems" (Lecture I).

THE ROYAL SANITARY INSTITUTE.—Friday, May 30, at 5.15 p.m., in the Royal Spa Rooms, Harrogate. Discussion on "Public Health Services—Are They Worth the Money Expended." To be opened by J. R. Kaye, M.B., C.M., D.P.H. Openers of the Discussion from the point of view of:—"Medical Officer," by J. J. Buchan, M.D., D.P.H. "Sanitary Inspector," by T. Foley Cass. "Health Visitor," by Miss A. Brooke.

AN EXHIBITION LITERATURE SCHEME.—Messrs. Johnson and Phillips, Limited, have adopted a scheme of distribution of trade literature which has two points in its favour. Firstly, it avoids the wasteful lifting of pamphlets and catalogue by the general public and secondly, it makes unnecessary the carrying of heavy handfuls of printed matter by the really interested people. A caller's book is kept on the stand in the Palace of Engineering in which visitors can record what pamphlets and catalogues they would like sent to their offices by post. As one adjunct to the scheme the firm provide a well got up waistcoat pocket book with notes on the Johnson and Phillip products and a diary for the month, in which notes can be made of interesting items on the exhibits generally.

CONFERENCE ON SCIENCE AND LABOUR.—A conference on science and labour, organised by the British Science Guild and National Joint Council of the Trades Union Congress and Labour Party, will be held in the Conference Hall, No. 2 Palace of Industry, at the British Empire Exhibition on the 30th and 31st inst. Applications for tickets of admission to the conference should be addressed to the Conference Secretary, 15, Gower-street, W.C.1, to the Secretary, British Science Guild, 6, John-street, W.C.2, or to the Secretary, National Joint Council, 33, Eccleston-square, S.W.1. The subjects dealt with will be: (1) The place of science in Government. (2) Scientific research in relation to industry. (3) Co-operation of science and labour in production. (4) Science and the human factor. (5) Science in correctional education.

THE LATE MR. SAMUEL SPENCER.—We regret to record the death, which occurred at his residence, 8, Alfred Place, Kensington, on Friday, the 16th inst., in his 87th year, of Mr. Samuel Spencer, chairman of the firm of J. E. and S. Spencer, Limited, Wednesbury and London. Mr. Spencer commenced his business career at the Horseley Company, Tipton, in the year 1853; he was connected with this company for 25 years, during which period he acquired great experience in the manufacture and erection of all kinds of bridge and structural work, gas and water works appliances, &c. In 1878 Mr. Spencer joined the firm of J. E. and S. Spencer, and was elected in the same year an associate member of the Institution of Civil Engineers. At the time of his death, he was chairman of J. E. and S. Spencer, Limited, the Colonial Gas Association, the Ascot Gas Company, the Egham and Staines Electricity Company, also a director of John Spencer, Limited, tube manufacturers, Wednesbury, and of the Croydon Gas Company; it was only recently that he resigned the chairmanship of the Woking Gas Company. In addition to his very active participation in business, he represented the Ward of Vintry in the Court of Common Council since 1894, and was the fifth oldest, member of the Corporation of the City of London. Mr. Spencer had long won the esteem of all who knew him, and his unvarying courtesy had endeared him to a very wide circle.

RAILWAY MATERIAL AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 665.)

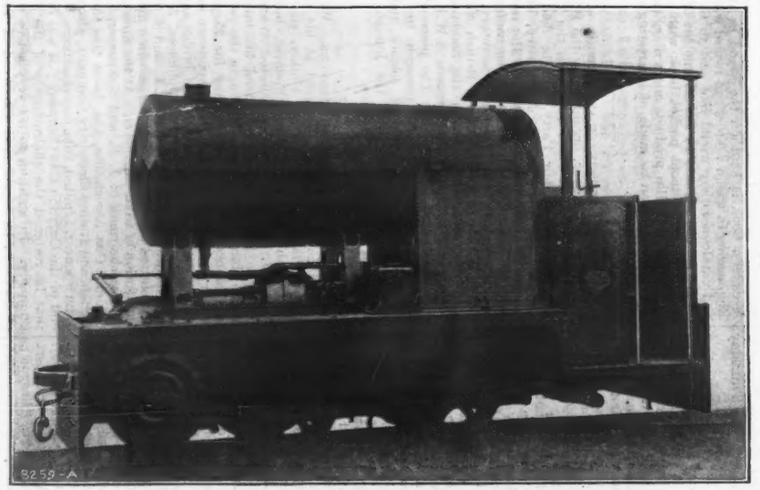


FIG. 56. NARROW GAUGE PETROL LOCOMOTIVE; THE DREWRY CAR COMPANY, LIMITED.

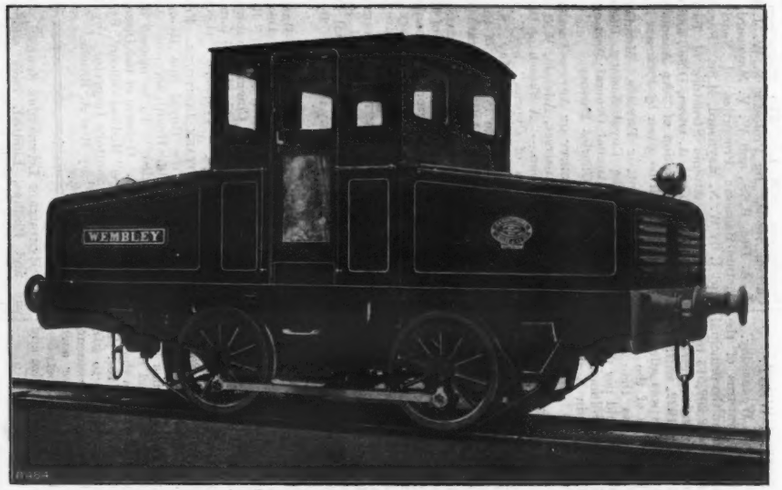


FIG. 57. ELECTRIC BATTERY SHUNTING LOCOMOTIVE; MESSRS. R. & W. HAWTHORN, LESLIE AND CO., LIMITED.

FIG. 58. LIGHT INSPECTION TROLLEY; THE DREWRY CAR COMPANY, LIMITED.

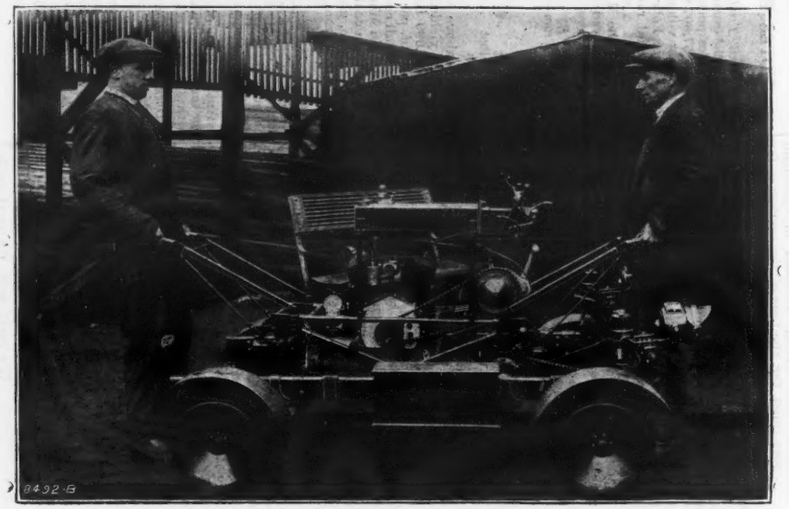


FIG. 59. LIGHT DREWRY INSPECTION TROLLEY; ENGINE UNIT BEING LIFTED OUT.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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One Two-Page Plate and Two One-Page Plates.—*THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.*

ENGINEERING.

FRIDAY, MAY 23, 1924.

NOZZLE EFFICIENCY.

THE third report of the Steam Nozzles Research Committee, which we reprint elsewhere, is of very considerable interest, both from the theoretical and practical standpoints. Mr. F. Samuelson, in discussing it, suggested that the efficiencies recorded were somewhat too low and that higher values were realised in practice. On the other hand, we are inclined to believe that it has hitherto been the practice to over-estimate nozzle efficiencies, and to make a compensating error by over-estimating the losses in the moving blades. The two points of view are not necessarily incompatible, since Mr. Samuelson does not say that the nozzles with which he has attained the excellent results he records, are geometrically similar to those tested by the committee, which were based on the designs in vogue when the experiments were commenced. These it will be remembered were formed by casting in division plates of uniform thickness throughout, and the earlier experiments of the committee indicated very clearly that advantage ought to result from modifying this plan and thinning away the exit edges, a practice which previously was, at any rate, far from common. Naturally, as soon as the Manchester data were available, many makers realised that a benefit would be obtained by this practice and adopted it without waiting for the results published in the third report, which show definitely that the modification suggested by the previous experiments constitutes a substantial improvement.

Particulars as to the American reaction tester mentioned by Mr. Samuelson will be awaited with interest, as some explanation is needed of the difference between the results obtained in America and in Manchester. It is difficult to believe that the type of apparatus used in Manchester is less reliable than the reaction type. In the latter as generally constructed, no steps have been taken to take the velocity out of the steam after it has cleared the orifice, but the jet has streamed through the discharge box at a very high speed, with the possibility, indeed probability, that the pressure distribution in the latter may be far from uniform. At Manchester, the kinetic energy of the escaping steam is destroyed by the porous pad on to which it is directed, and a careful exploration of different parts of the discharge box has demonstrated a remarkable uniformity of pressure.

That the Manchester experiments are exceptionally precise seems to be demonstrated by the fact that they appear to be the first in which it has been possible to detect a reduction in the efficiency as the superheat is increased. Such a reduction we know from theory must occur, since with a stated pressure the hotter the steam the greater is its kinematic viscosity, and other things being equal it is well established that frictional losses are greater the higher the kinematic viscosity of a fluid. The great gain observed in practice with high superheats is in fact not due to a reduction of friction, but to a diminution of the supersaturation losses.

Unfortunately the law connecting friction in a nozzle with the viscosity of the fluid traversing it, is quite unknown. All we can say is that if this friction be expressed as a fraction of the total head, this fraction must be capable of being expressed in terms of Reynolds function $\frac{\nu}{v\,d}$ where ν denotes the kinematic viscosity of the fluid, v the velocity of efflux and d some characteristic dimension of the nozzle. This rule, of course, will break down with velocities approaching the critical, at which the compressibility of the vapour can no longer be neglected.

Had the research been concerned with the efflux of liquids there would have been no difficulty in reducing all the observations to a common basis, by means of Rayleigh's law of corresponding speeds. According to this law, using one and the same nozzle, the frictional losses (expressed as a fraction of the head) will be identical at speeds proportional to the kinematic viscosities. Thus had the experiments been made with water and alcohol, the frictional loss, expressed as a fraction of the head, would be the same with the two fluids, when the water had a velocity of efflux equal to 100 ft. a second, and the alcohol a velocity of 125 ft. a second, these figures being proportional to the kinematic viscosities of the two fluids at 0 deg. C. With an elastic vapour like steam, however, no such simple adjustment of observations to a common basis is practicable, because the kinematic viscosity varies from inlet to outlet, and thus, if experiments were adjusted on the basis of the conditions at discharge, they would not be in adjustment for the conditions at entry. Until the law, connecting nozzle friction with viscosity, is definitely established, adjustments of observations to a common basis will remain impracticable in the case of elastic fluids. One conclusion follows very directly from the above considerations, viz., that the Manchester experiments must be somewhat more precise than would be estimated from the divergencies of the plotted points. In fact if two experiments are made with the same theoretical velocity of efflux the efficiencies obtained must necessarily be different unless the kinematic viscosity of the fluid is the same in the two experiments. Hence some of the divergencies must be due to this factor and, thus, not attributable to errors of the apparatus or of the observers.

Fortunately, from experiments on pipes, we are justified in assuming that in general the effect of changes in the viscosity will be small, but it does exist. Moreover, though generally small, we know that near the critical region in which viscous flow changes to turbulent flow, quite small changes in the viscosity may have disproportionately large effects. It seems possible, therefore, that the greater divergences of the observations at low speeds shown by the diagrams, may be not wholly attributable to the difficulty of measuring accurately small pressure differences and small impulses, but also to the fact that at these speeds changes from viscous to turbulent flow are in progress.

The question of a scale effect was raised by Mr. Pochobradsky. Such an effect does exist, but theory shows us that exactly the same efficiency should be attainable with small nozzles as with large ones geometrically similar in form. The only difference is that the conditions, in which this maximum efficiency will be obtained, will not be the

same in the two cases. Similarly, were the losses observed at Manchester due to friction only, the maximum ordinates of the two curves in Fig. 14 (see page 685) should be the same. This would appear not to be the case, and since the lower maximum was attained with the hotter steam it would seem reasonable to conclude that part of the losses observed were due to an escape of heat by radiation, convection or conduction, which will follow a different law than losses by fluid friction. Such a heat loss would obviously be proportionately less important the greater the mass flow, and would thus be greatest at low velocities.

It is of interest to note Mr. I. V. Robinson's observations that in consequence of the work of the committee, manufacturers are now building impulse turbines with more stages, thus reducing steam speeds to values which the tests indicate as those at which nozzle efficiencies are highest. This represents a great change from ideas formerly prevalent, where the aim seemed to be to run at the highest possible speeds. Turbines constructed on the latter lines have the advantage in the matter of manufacturing costs, but to-day station engineers seem prepared to pay for high efficiencies, so that the movement will probably spread. In certain cases, we understand, the gain thus secured is being attributed to various subsidiary details, which, in most instances, involve considerable increase in cost, although the new variants are not one whit superior to those they are intended to replace.

It is important that those who are responsible for manufacturing policy should realise what are the conditions upon which high efficiency depends as these, fortunately, are open to be adopted by all.

THE MOUNT WILSON OBSERVATORY.

ALTHOUGH the results of the researches at the Mount Wilson Observatory are published with all due speed, the issue of the annual Report gives the most comprehensive view of the activities of the institution, both in regard to the increase of equipment and of its employment in advancing astronomical and physical research. Since the provision of equipment is essential to progress, we may note among the more conspicuous triumphs achieved, that the mechanism for the ruling of optical gratings has reached a state on which the staff may be congratulated. To construct a grating 13 cm. by 8 cm. is no small feat, and now it has been found possible not only to construct gratings of this size, but to rule them in such a way that the brightness may be concentrated at will in the spectrum of either the first or second order. This important result has been achieved by the construction of a specially designed machine for shaping the diamond point to the required form quickly and accurately. Experiments will probably be carried on for many years yet, in the hope of attaining a yet higher standard of excellence, but already with the recently ruled grating the time of exposure required to photograph the spectra of sun-spots has been reduced to one-twelfth of that necessary with the best gratings hitherto procurable.

Another instrument to which interest attaches on account of its unique character is the 50-ft. interferometer, with independent equatorial movement, to replace the 20-ft. instrument with which such startling discoveries were made. The need for greater accuracy and the possibility of acquiring new facts are shown by the unexpected alteration in the measured diameter of α Orionis, due presumably to variations in the light and radial velocity of the star.

The connection between electrically exploded wires and astronomy may seem remote, but in these experiments the behaviour of matter under forces and at temperatures approaching those existing in remote worlds can be studied, and the opportunity for new tests and enquiries is furnished. The temperature reached is of the order of 20,000 deg., and when the explosion is successfully made the resulting cloud of uniform incandescent, metallic vapour totally absorbs light from a brilliant source. No trace of gas is found in the bulb, though 26,000 volts be applied, affording certain proof that under this violent disruption no decomposition of the heavy metallic atoms into helium or other gases takes place.

To obtain the vacuum spark spectra, whose revelations are so interesting, a large condenser is discharged between metallic electrodes, separated about 2 mm. in a good vacuum. The maximum value of the momentary current flowing through the gap is about 10,000 amperes. In the brilliant spark produced many new lines are seen in several metals, calcium showing about 900 lines in the ordinary photographic region, very few of which can be identified with known lines of this element, which suggests that a state of ionisation is attained decidedly beyond that reached in ordinary sources.

It is impossible to mention the many investigations in which the 100-in. telescopes and other instruments have taken part, demanding the attention of a large staff. Many of these enquiries have grown from the experimental stage to be matters of routine, whose conclusions will pass into text-books in the form of statistics. Other enquiries, as that of Michelson on the determination of the velocity of light, and by Abbot on the measurement of the energy of the spectra of certain bright stars, are still in progress, and can be referred to later. Attention may, however, be briefly directed to some researches that, for the time at least, are finished: among these are included the internal motions of light spots in spiral nebulæ, indicating rotation or motion of matter outwards along the spiral arms, confirming the brilliant theoretical work of Dr. Jeans; the radial velocities of long-period variable stars, and investigations of the Zeeman effect in the spectra of certain elements. Among discoveries, apart from the results of long-continued research, may be mentioned the detection of a nebula which reproduces in miniature all the characteristics of the Magellanic clouds. Within an area of less than one-twentieth of that of the moon can be counted patches of distinct nebulosity, planetary nebulæ, and variable stars—presumably a distant galaxy.

Finally, our neighbouring planets Mercury and Venus have been submitted to a searching scrutiny, cunningly directed, and they have preserved their secrets well, science for the moment having to admit a repulse. We do not yet know the time in which Venus rotates on its axis nor the direction in which that axis points. It has been suggested that the equator of Venus is nearly perpendicular to the plane of the planet's orbit, or alternatively, that Venus rotates in an opposite direction to that of the earth and Mars. There is no confirmation of these improbable assumptions, and in the absence of direct testimony the observers will do no more than assert that the chances are about ten to one in favour of the period of Venus being longer than 20 days. Mercury, which offers few opportunities for evening observation, speaks also with an uncertain voice. Some evidence is afforded that its atmosphere, like that of the moon, is negligible in amount. This leads to the surprising conclusion that the temperature of the illuminated surface is about the same as that of the moon. More accurate observation of these comparatively near objects gives little support to the generally accepted views of earlier astronomers.

THE ROYAL SOCIETY SOIRÉE.

(*Concluded from page* 648.)

CONTINUING our description of some of the exhibits at the Royal Society Soirée, we note the method of measuring ultra-violet radiation which Messrs. A. Eidenow, Leonard Hill, F.R.S., and A. Webster exhibited, and which they use for physiological research. A solution of acetone and methylene blue is prepared and exposed in a standard quartz tube to the bleaching ultra-violet rays. The amount of bleaching is determined by comparison with a set of standard tubes of varying methylene blue concentrations.

Professor E. N. da C. Andrade and Mr. J. W. Lewis exhibited a relatively simple apparatus exemplifying the vortex motion of viscous liquids between two rotating cylinders. Professor G. I. Taylor described an apparatus of this kind, which is of value for the study of hydrodynamics, last year in the Royal Society; he squirted the liquid into the annular space between the two cylinders. To facilitate the optical examination, Professor Andrade makes the inner cylinder a vertical rod of silver steel, 5 mm. in diameter, the outer a glass tube, 10 mm. in diameter, and charges the space between the cylinders, both of which can be rotated about their vertical axes, with colloidal silver. As long as everything is at rest, the observer sees fine specks of silver. When rotation is applied, the specks move; at a certain speed of the inner cylinder the motion becomes vortical, left and right vortices alternating. The vortices may be likened to the spiral motions of the particles of smoke rings, and the observer, looking horizontally at the liquid, watches the movements taking place in rings superposed upon one another, like a series of rubber rings pushed on to a stick. To minimise optical distortion, the outer cylinder turns in a cubical glass box, lubricated with a liquid of the same refractive index as the glass; the observer looks into this glass cube.

Neon lamps were utilised in two novel pieces of apparatus for different purposes. The International Western Electric Company uses a neon lamp for producing an even time scale in connection with the cathode-ray oscillograph, which we described last year in connection with Sir Ernest Rutherford's lectures.* The apparatus consists of a valve oscillator, the oscillograph and a neon lamp, which is made to flicker at an adjustable rate. The simple potential curve of the oscillograph would be a straight, vertical line, representing the to-and-fro potential oscillations. When the flickering neon lamp is joined to the circuit, the line is spread out horizontally, and a wave is seen to traverse the fluorescent zinc-silicate screen of the oscillograph. When the oscillator and lamp are in synchronism the wave appears stationary; when the neon lamp flickers at half the rate of the oscillator (whose frequency is to be determined) two complete waves are seen. By changing the frequency of the circuit, waves of 25,000 and even 50,000 periods per second may so be examined.

Professor J. T. McGregor-Morris and Mr. L. E. Ryall make use of the fact that a neon lamp strikes at a definite potential (in their case 162 volts), provided the frequency of the supply source exceeds a certain minimum (7 cycles), for measuring the maximum voltage of a supply. A variable condenser and the lamp are joined in series with a fixed condenser; this system is placed across the alternating supply, and the capacity of the variable condenser is gradually diminished until the lamp strikes; then $V_{max.} = V_n\ (1 + C_v/C_f)$ where V_n is the striking potential and C_v and C_f indicate the variable and fixed condenser capacities. Instead of watching the lamp, Professor Morris listens at a telephone; as he varies the capacity, the telephone suddenly emits a sound, and the overall maximum voltage can readily be obtained. Potentials up to 10,000 volts at 1,600 periods have so far been determined by these means, but the range could probably be extended to radio frequencies.

The first of two high-pressure bomb instruments exhibited was the new isothermal calorimeter of the Explosives Branch, Woolwich Research Department, shown by Mr. C. G. Jackson, and designed to measure the rate of heat evolution from compounds undergoing slow decomposition. The bomb is a sphere, 7 in. diameter, 2¼ in. wall thickness, weighing 50 lb., which is made of a special alloy steel of low heat conductivity. The detachable upper portion, which screws into the body of the bomb, carries the container for the substance, *i.e.*, the calorimeter box. It is fitted with six thermojunctions of Eureka metal and iron, which measure the rise of the container temperature, which can be kept equal to that of the inner wall of the bomb within 0·0001 deg. C., and counter-balance this rise by sending a cooling current through the one Peltier junction. The whole bomb is immersed in a thermostat. The other bomb was that used by Professor W. A. Bone, F.R.S., for obtaining high-pressure time curves in researches especially upon the activation of nitrogen in carbon-monoxide-air explosions at high initial pressures. The bomb (3 in. in diameter) is made of nickel steel and is provided with a Petavel manometer

* See "Atomic Projectiles," ENGINEERING, February 23, 1923, page 243, Fig. 3.

capable of resisting sudden pressure rises of 1,000 atmospheres; the initial pressures are varied between 3 and 100 atmospheres, and the gas mixtures experimented with consist of hydrogen, oxygen and nitrogen, and of carbon monoxide with additions of oxygen, nitrogen, or argon in binary or ternary mixtures.

The demonstration by Mr. W. R. Macdonald, of the Anglo-Persian Oil Company, of the selectivity of lightning discharges was not quite in accord with popular views. A large hollow metal tray had been filled with several inches of soil; the tray was connected to one pole of an induction coil giving sparks of 100,000 volts and more; the other pole was a wire attached to a horizontal arm so as to swing over the ground, the point of the wire being about 6 in. above the ground. Four metal washers were placed on the ground at the corners of a square. At first no discharge passed between wire and washers, but when one of the washers had a short piece of wire about ¼ in. long attached to it, representing a lightning conductor, this washer was struck, but there was no secondary discharge over to the other washers. When a fifth washer was placed in the centre of the four and provided with a lightning conductor, this washer was struck and copious sparks passed over to the other washers. When the central washer was further provided with an earth wire (not reaching quite down to the metal tray), this washer was again struck, but the discharge did not spread. The earthed central washer hence protected the others, but one would have expected it also to have protected them when not earthed. The experiments, however, have so far been made on too small a scale, and too much depends upon relative dimensions and distances to justify general conclusions.

Of the manifold biological and physiological exhibits we can only refer to Professor P. Groom's studies of the fungi which cause dry rot, made in connection with the researches of the Cold Storage Department. Moisture is required for the growth of these fungi, which sometimes grow at an amazing rate; but some of those studied, which all grow in timber, when once established, can attack the driest wood, since they themselves exude moisture. The fusty smell of these fungi is very objectionable in cold storage. Fortunately, only a few of them can advance over or through other materials, such as brick walls.

THE NAVY AT THE BRITISH EMPIRE EXHIBITION.—I.

VISITORS from the British Isles and from the Overseas Dominions to the Empire Exhibition will assuredly evince a far keener and more active interest in those exhibits which are concerned with the British Navy than has been the case in any previous great Exhibition. The Navy has always been a source of pride to all citizens of the British Empire, for it was rightly recognised that upon its initiative, its force, and its efficiency the foundations of the Empire had been laid and its fabric erected and maintained. Large amounts of money had been cheerfully voted year by year for its upkeep and expansion, the taxpayer considering these sums as a very reasonable premium for ensuring the safety of the Empire and the protection of its oversea communications. The man-in-the-street had some shadowy notion of the purpose and use of the Navy in time of war, but was wholly unaware of the relentless force which seapower could exercise. The Great War was the object lesson which taught all this, and it brought home, more particularly to the inhabitants of the British Isles, the extent of their dependence on British shipping and upon the freedom of the seas and its maintenance by the British Navy. Thousands, who would otherwise have had no need nor occasion so to do, have served during the war in ships of the Royal Navy or in those of its many auxiliary forces, whilst many millions proceeded to and from the various theatres of war in distant lands securely protected by the convoying warships. Those with such personal experiences, and who have long since returned to their normal occupations and professions, will be glad to renew their acquaintance with naval matters, whilst others, who perforce had to stay at home, will have been told by their friends and relatives, or read in the Press or in histories of the war, of those gallant exploits, the superhuman endurance and cheerful performance of duty of the men who served afloat, and will be interested in the ships which carried them. Such a combination of circumstances had not been the lot of British citizens for over a century, and it is for these reasons the Navy exhibits at Wembley will be most noticed and carefully studied. For there can be seen excellent models of all types of ships used for war and mercantile purposes, whilst anyone with the necessary time and inclination can see and examine the multitudinous and complicated appliances and fittings which are portions of that wonderful jigsaw construction, the modern ship.

At such an Exhibition, two sides of the subject should be presented—the historical and the modern or up-to-date. The former must be left to Government Departments, assisted by those societies and associations which take an interest in such matters, to prepare and arrange; whilst the other aspect is exhibited by the many shipbuilding, marine, engineering and other firms, which show their specialities in the Palace of Engineering.

It is perhaps more instructive and interesting for a visitor to such an Exhibition to see the historical side at the outset, for he will notice many exhibits which by comparison with those on the modern side emphasize or indicate the growth and development of the particular subject in which he is interested. For this reason the Pavilion of His Majesty's Government, for which the many Departments of State have prepared exhibits showing the nature and extent of their activities, should first be visited.

In this building the exhibits of the Navy, as is right, occupy the most prominent positions. On entering and looking over the balcony to the Court of Honour below, a relief map of the world set in water, and constructed on Mercator's projection, is seen occupying the central position. The miniature oceans are traversed ceaselessly by small model ships moving along the great sea routes, thus emphasizing the necessity and duties of that great mercantile marine possessed by the British Empire. The map and the lines of ships also convey an idea of the duty which the British Navy has to perform in time of war in protecting the trade routes from enemy raiders, and the difficulty, which was encountered during the Great War, of finding and destroying the German raiders in the wide expanses of ocean. The North Sea, the main theatre of naval operations from 1914 to 1918, appears insignificant in comparison with the oceans as viewed on the map.

Adjacent to the world map is the Admiralty theatre, with a water stage 70 ft. wide, on which it is proposed to enact important episodes in naval history, including the defeat of the Spanish Armada and the Battle of Trafalgar. At present the attack on Zebrugge on St. George's Day, 1918, occupies the stage, the whole of the operations being carried out in a realistic manner which gives the spectators some idea of the nature and difficulties of the undertaking. Possibly a slightly greater light over the stage would enable them more easily to follow the movements in detail.

On the same floor and in Room No. XIV models of various types of British warships are exhibited, these having been constructed by the firms who built the vessels. All models are complete and excellent in the execution of their details. One Dreadnought, the Hercules, built by Messrs. Palmer, of Jarrow, is included in the series, and the Agamemnon, the last battleship of the pre-Dreadnought era, built by Messrs. Beardmore, also finds a place. The Furious, a large light cruiser built in just under two years by Messrs. Armstrong, is the only one of the larger warships ordered during the war whose model is exhibited. Intended to mount one 18-in. gun in a turret one forward and one aft, compared with pairs of 15-in. guns on the sister vessels Glorious and Courageous, she was modified by taking out the forward turret and adding a deck from which aeroplanes could fly off. The three vessels are now undergoing further modification for conversion to aircraft carriers. The light cruisers Dauntless, built by Messrs. Palmer, and the Champion, by Hawthorn, Leslie and Co., the flotilla leader Scott, by Cammell Laird, and the destroyers Warwick, by Hawthorn, Leslie, and Radstock, by Swan and Hunter, are represented. Patrol boats P. 15, 16 and 17, built by Messrs. Workman, Clark, three of many similar vessels built especially for anti-submarine work, and the shallow-draught Tigris gunboats Mantis and Moth, designed by Yarrow and built by the Sunderland Shipbuilding Company, also find places in this room.

Submarines of the K, M, and E classes are on view, and amongst these is an instructive model of E.29 lent by the Imperial War Museum. This submarine was built by Messrs. Armstrong, who also constructed the model representing a longitudinal, vertical section of the vessel. The hull construction, frames, bulkheads, flats, tanks, &c., are all indicated, as also are the engines, motors, batteries, torpedo tubes, and all other fittings installed on the port side of the submarine. The model shows the crowded character of the interior of these craft, which played such an important part in the Great War.

But perhaps the most interesting model is one constructed by Messrs. Thornycroft, and which represents the complete arrangement of the upper works of the Hyderabad, a Q or mystery ship—a class made famous by the exploits of Captain Campbell, V.C. The model shows how the guns were concealed, and how, when the occasion arose, their covers fell away, the bulwarks in front were lowered, and they were brought into action—the vessel before this retaining the appearance of a peaceful and harmless merchantman proceeding on her ordinary routine work.

In addition to the models, paintings by eminent artists depicting incidents in the naval operations of the war are hung on the walls, which are also ornamented with the badges of many warships now in commission.

It is probable that limitations of space prevented the addition of those other types of vessels—trawlers, drifters, minesweepers—which played a less exalted but extremely useful part in four years of war. The monitor type is also a notable absentee.

The room adjoining that allotted to the Navy contains exhibits illustrative of the work of the R.A.F., and amongst these is a lay-out of a seaplane and aeroplane base. A model of the aircraft carrier Argus occupies a prominent position in this exhibit. As one of the first vessels fitted for the purpose of carrying aeroplanes, with a deck for flying off and on to, she is likely to become historic. Originally laid down, and almost completed as an Italian mail steamer, by Messrs. Beardmore, she was purchased by the Admiralty and converted by the firm for her new duties. The long wide and clear flight deck, the absence of the ordinary vertical funnels which give her an appearance of helplessness, and the great height of freeboard, are the distinguishing features of this pioneer in a special type of vessel rendered necessary by the adoption of the aeroplane for naval purposes. Already the Navy has two other aircraft carriers in commission, the Eagle and Hermes, but these, unlike the Argus, have vertical funnels. The value such vessels will have in future naval operations has been quickly recognised by all naval authorities, and limits to the individual size and aggregate tonnage to be built by the various powers have been agreed to in the Washington Treaty. Only for capital ships have similar limits been imposed.

In the same room is a fine model of the Great Michael, a Scottish man-of-war built in Scotland in 1506 by Jack Tarrant, a shipwright whose services were lent to the Scottish king by his ally the King of France. She was the largest warship of her time and is said to have measured 240 ft. long and 56 ft. beam. The model is very complete in all details and shows she had four masts—fore, main, mizen and bonaventure—each fitted with a huge fighting top in which javelins are shown and also a swivel gun. The main mast has a second and smaller top. Her huge forecastle and poop erections bristle with small guns, larger ones being fitted on the upper deck in the waist, and also between decks. The impression given is one of excessive top hamper, and this is perhaps confirmed by the fact that she foundered in the English Channel in 1512. From the historical point the model is interesting as representing the type of "great"

ship then in use, and with which King Henry VIII inaugurated the modern English Navy when he built the Henry Grace de Dieu or Great Harry in 1513. The type—the sailing line of battleship—was that from which was gradually evolved the capital ship which fought at Trafalgar.

Outside the room in which this model is placed, and situated in the Hall of Honour, is a case containing a series of models which illustrate the evolution of the fighting ship up to the time of the Great Michael and the Great Harry. Here one can see a model of the ship or long boat in which the Danes and other northern nations descended on the shores of Britain. These were open boats 50 or 60 ft. long fitted with a mast amidships on which was hung a yard and squaresail. In the absence of a favourable wind 16 oars a side could be used and the vessel steered by an oar over the starboard quarter. The shields of the crew are ranged along the top-sides to act as a protection. Another model shows the next stage in evolution when a platform or castle supported by pillars from the main hull was added forward and aft and in which the fighting men took up positions when an attack was intended. A third model shows the next stage when the pillars were omitted, and the framing and planking of the hull were continued to the level of the two platforms, and supported them. A yard and square sail were still carried on the mainmast, and a top had been added together with much smaller squaresails on the poop and forecastle, the masts for these being primarily intended to carry flags and banners only. Another model shows an intermediary type between the third and that represented by the Great Michael. Sailing on a wind was then coming into fashion and sails were increasing in number and size. At the time of our visit these models were not finally arranged, no descriptive cards being attached to them. It is understood to be the intention to use these models on the Admiralty water stage as a portion of a pageant to illustrate the evolution of the fighting ship during a period of one thousand years.

The historical side of naval matters is supplemented by a selection of old prints lent by Major Macpherson from his very extensive collection. Here may be seen a picture of the Great Harry under full sail, and also one of the Sovereign of the Seas, designed for Charles I. by Phineas Pett and built by his son Peter at Woolwich, in 1637. A series of drawings of famous ships from the Admiralty records will also be added to the section.

The rooms allotted to Army exhibits contain a few which are of interest from the Naval point of view, as showing the types of guns which were mounted in earlier ships. The first of these is a bombard found in the moat of Bodiham Castle, and dating from the early 15th century. It is about 3½ ft. long and fired a stone shot 15 in. diameter and 160 lb. in weight. The chamber is about 9 in. diameter and half the total length, the muzzle portion being about 18 in. outside diameter. Built of forged iron strips welded together, the muzzle is lined with cast-iron, a very early instance of the use of this material. The bombard is not fitted with trunnions, but is recessed for half its depth into a heavy baulk of timber, two half-hoops, one around the breech and the other round the forward portion keeping it in place. (See Fig. 1.) The wooden bed is mounted on two truck wheels, each about 9 in. diameter and 6 in. broad; the trail of the bed rested on the ground, a pit being dug for it to rest in, if greater elevation were required. The touch-hole or vent is protected by an iron staple, which also served as a guide for the red-hot end of the poker with which the bombardier fired the charge. Bombards such as this, were carried in men-of-war of the 15th and 16th centuries. They weighed between 4 cwts. and 5 cwts. apiece, and were the prototypes of the 16-in. gun, weighing just over 100 tons, which is exhibited by Messrs. Vickers in the Palace of Engineering.

A second type of early gun termed a peterara or chambered gun, largely, if not primarily, used in ships, is on view in the same room, and is stated to have been constructed between 1461 and 1483. It is a breech loader, the chamber containing the gunpowder being portable and shipped into a slot or recess at the breech end of the main portion—the hall—of the gun. (See Fig. 2.) The chamber is made of conical form at its forward end, and this is forced into a corresponding recess in the hall by a wedge driven through a slot in the breech of the hall, and bearing against the solid end of the chamber. The hall of the gun is built of longitudinal iron strips welded together and reinforced around the barrel by iron rings shrunk on. The gun has trunnions which fit into holes in the forks of a crutch, the spindle of the latter shipping into a socket on the bulwark or rail of the ship. The main portion of the gun is 3 ft. long, an iron stock a foot in length allowing a gunner to direct it. The calibre is 2½ in., corresponding to a shot of 2 lb., the gun itself being 125 lb. An elevating sector connected to the trunnion crutch, has an arm on either side of the breech, and is drilled with holes to take a bolt on which the breech rested, thus allowing for varying the angle of elevation. As three or four chambers were supplied to each gun, this type was the quick firer of the time. Similar guns are shown mounted in the tops of the Great Michael, and the armament of ships at the end of the 15th century was almost wholly of this nature, the Sovereign in 1496 mounting 140 of them.

A third gun, dating from the 14th century, and thus one of the earliest, is also exhibited. It is a plain tube, reinforced by hoops and fitted with two

Fig.1.

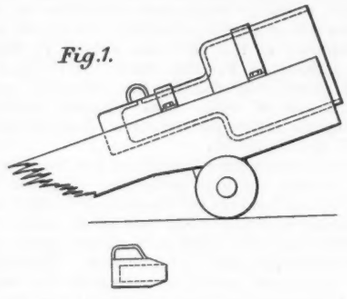
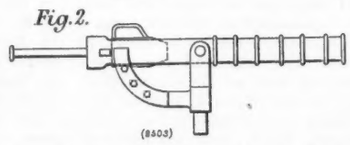


Fig.2.



(8503)

ring-bolts for slinging. The carriage is formed of two wooden trestles, on which the gun rests, with a sloping shore against the breech to take the recoil. The gun is about 2 ft. long and 4 in. outside diameter.

Another exhibit which is of some interest, consists of three models prepared by those engaged in the work of salving bullion from the wreck of the Laurentic sunk during the war. The models show the gradual collapse of the structure of the ship in a vertical direction, the decks slowly sinking on to the keel and rendering the task of securing the treasure extremely difficult.

Before leaving the Government Pavilion a visit should be paid to the exhibit prepared by the Hydrographic Department of the Admiralty; this illustrates a branch of naval activity which is sometimes forgotten, but which is of the utmost importance to the safety of all those whose business it is to go down to the sea in ships. It is the work of this department to survey the beds and shores of the Seven Seas and from these surveys to prepare the drawings from which the charts are engraved and finally issued to ships for navigating purposes. Prior to 1671 English seamen were almost wholly dependent on the collection of charts which had been prepared by Dutch navigators, and the originals of some of these charts are amongst the exhibits. One of these, the "Mariner's Mirror," a combined chart-atlas, was published in English in 1588, and is interesting from the historic point of view, as the charts are embellished with little drawings showing the principal types of vessels and their rig met with in the various seas at the time. In 1671 "The English Pilot," compiled by John Sellers, an Englishman, was published. Sellers utilized the information given in Dutch and other foreign charts, and for his work he was given the title of Hydrographer Royal. It was not until nearly the end of the 18th century that the Admiralty established a Hydrographic office for this work appointing a civilian in charge. His successors have all been naval officers who have previously had considerable experience in the work of surveying. At the present time nine or ten of His Majesty's ships are continuously engaged in various parts of the world in the work of survey. A model of the Endeavour, one of these surveying ships, is exhibited, the methods adopted for obtaining the depth of the water of sounding being clearly shown. Typical drawings indicating the information sent home by the surveying ship; the drawing prepared from these for producing the finished chart; the etched copperplate of the latter; and finally the engraved chart as issued to ships are also to be seen. Some of the various instruments used in nautical surveying are also included in the exhibit.

A collection of original surveys carried out by famous navigators, or of portions of seas or harbours which have become important or historical is also of interest. Amongst these is a survey by Captain Cook; and a large one taken in 1812 of Scapa Flow, to which a proposal was attached that it should be used as a rendezvous for a squadron of battleships of the line. Just over a century afterwards the proposal was adopted.

The exhibit is completed by a diagram representing the latest method of taking a sounding. Originally this was done by letting down a line to which a heavy lead weight was attached and measuring the line paid out when the bottom was reached. Later, a small glass tube closed at the upper end was inserted in the lead, and by the rise of the water into the tube, shown by the mark on a chemical coating on the inside of the glass, the depth of water was obtained. The latest method—the Echo or Sonic—employs neither line nor lead, but a beam of sound. A transmitting instrument in the bilge on one side of the surveying ship emits a sound which is reflected from the bottom and received by a hydrophone fitted in the bilge on the opposite side of the vessel. The interval of time between sending out the sound and receiving the echo, in conjunction with the velocity of sound through sea water, gives the depth of the sea at the point of observation. The apparatus which is of small size is also exhibited and it is stated has given good results for moderate depths of water.

NOTES.

ALCOHOL AS A MOTOR SPIRIT.

THE efforts which have been made for several years past in France to utilise alcohol as a motor spirit in the place of petrol have been followed with great interest generally. The object of the researches, apart from the question of economics, was to render the country independent of foreign supplies of petrol. That these researches have failed so far will be viewed with regret by many. Information on this matter is given in a recent article by Colonel Ferrus, published in the Journal of the French Automobile Club. In an introduction to this Colonel Ferrus states that in order to dispose of the national stocks of alcohol which had accummulated in execution of a provisional war decree of June 30, 1916, a law passed on February 28, 1923, compelled the importers of petrol to purchase every month from the State, and for use as a motor spirit exclusively, a quantity of absolute alcohol corresponding in volume to 10 per cent. at least of the quantity of petrol they imported. The law came into force on October 1, 1923, and the importers of petrol were to have purchased from the State in October, November and December a quantity of alcohol at 100 deg. (in reality 99·7 deg.) amounting in volume to 10 per cent. of the 180,000 tons of petrol imported, or about 240,000 hectolitres (about 5,000,000 gallons). But the State itself has not been able to carry out the law; it has not been able to supply to the petrol companies more than a very limited proportion of the quantity of absolute alcohol referred to. There is no deficiency in the commercial alcohol supply, the stocks increased in 1923 by about 700,000 hectolitres (about 15,000,000 gallons); the difficulty lies in dehydrating the available alcohol, and the whole measure thus far has resulted in a loss. Colonel Ferrus estimates that if the scheme for

using alcohol as a motor spirit were to be abandoned, the direct saving to the country would amount annually to 100,000,000 francs, whilst the indirect annual saving would be about 340,000,000 francs, owing to lesser sugar imports to the extent of 420,000,000 francs, from which should be deducted an increased importation of petrol to the amount of 80,000,000 francs.

THE DEVELOPMENT OF THE KENT COALFIELD.

An interesting stage in the development of the Kent coalfield was reached on Monday last when the work of sinking the downcast shaft of the new Betteshanger colliery was formally inaugurated. The site of the colliery is located near Northbourne, some two miles west of Deal, where borings have indicated the existence of seven workable coal seams having a total thickness of 32 ft. It is proposed, in the first instance, to sink two shafts to a depth of 866 yards at Betteshanger and to start mining operations in the third seam of the series, this seam being about 3 ft. 10 in. in thickness and being situated at a depth of 716 yards; the intention is eventually to develop the colliery for an output of about 750,000 tons per annum. Water is likely to be encountered in large quantities in the sinking operations, a borehole on the site having indicated the existence of Greensand water at a pressure of 295 lb. per square inch at a depth of 875 ft., and Hastings water at a pressure of 112 lb. per square inch at a depth of 960 ft.; the top of the coal measures is situated 975 ft. below the surface. The cementation process will be employed to combat the water in the upper chalk, while tubbing will be used in the lower part of the shaft. Both shafts will have a clear internal diameter of 22 ft., and will be lined with concrete. The headframe for the downcast shaft has been erected, and the winding engine for this shaft is in operation, while the engine for the upcast shaft is in course of erection on the site, it being intended to use the permanent equipment for the sinking operations as far as possible. Steam will be supplied by four Stirling boilers, of which two are already under steam. The boilers, which are fitted with superheaters and have Babcock & Wilcox chain-grate stokers, are each capable of evaporating 25,000 lb. per hour, the working pressure being 200 lb. per square inch and the superheat 200 deg. F. The electric power station, now under construction, will at first include two 1,500 kw. Parsons' mixed-pressure turbo-generators operated partly by exhaust steam from the winding engines, while two high-pressure turbo-generators of 3,000 kw. and 5,000 kw. capacity, respectively, will be installed later. Offices, machine shops and other buildings have been completed, and a single line standard gauge railway track has been constructed to connect the colliery with the Southern Railway line between Sandwich and Deal. These will, of course, facilitate the preliminary work, which, we understand from Sir Hugh Bell's remarks at a luncheon given in connection with the inaugural ceremony, will occupy some four or five years. The work has been carried out by Messrs. Pearson and Dorman Long, Ltd., of 19, Victoria Street, S.W. 1, of which company Sir Hugh Bell is chairman. We understand that the Company has acquired, or has arranged to acquire, the mineral rights under about 60 square miles of the Kent coal area, and that the sinking operations and equipment of the Betteshanger colliery constitute the first step towards the development of the Company's property.

THE LATE MR. J. P. COPLAND.—The well-known Glasgow consulting engineer, Mr. John Pearson Copland, who designed many water supply schemes and sewage works, died at the age of 56 years at his residence, Carlowrie, Lenzie, on Monday, May 12. He was the son of Sir William R. Copland, M.Inst.C.E., who was Chairman of Governors of the Royal Technical College, Glasgow during the period when the funds were raised for the erection of the present well-equipped buildings. Mr. John Copland served his pupilage under Mr. James Reid and then, in 1889, joined his father. On the death of Sir William, in 1907, the practice of gas, water, dock and harbour engineers, was continued by his two sons, Mr. W. R. M. Copland and the subject of this notice. Many of the water supply schemes in the West and North of Scotland were designed by them as well as those of Great Malvern and the Tarapaca works at Iquique, South America. Mr. Copland was a Member of the Institution of Civil Engineers and rendered useful service as a member of the Trades House and as an office bearer of some of the Incorporations and benevolent societies of Glasgow.

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

WHEN the British Empire Exhibition scheme was started it was decided jointly by the Mining Association of Great Britain, the Miners' Federation and the Institution of Mining Engineers that a full-size representation of an actual working colliery should be arranged, with all the essential features of a modern high-class installation.

Plans were made by Mr. H. M. Crankshaw, the Director of the Mining Exhibit, and the co-operation of the constructors of mining machinery was obtained for the loan of everything required from the winding engine to the miners' lamps, including large subsidiary plant for screening and washing the coal. In elaborating the scheme it was necessary to arrange the exhibit so that the circulation of the public should take place in one direction, and for this reason the surface plant shown in the plan (Fig. 1, page 678) is first examined by the visitor, who passes through the engine room to the lamp room and other surface buildings, past the air compressor and upcast fan to the screening and washing plants and thence to the cages by which descent is made to the main heading. The site has been selected on sloping ground so that after going round the workings the visitor can walk out into a hall containing an exhibit of models illustrating the history and development of coal mining and dealing with boring, shaft-sinking, pumping, ventilating, geology, and the various methods adopted for working.

There are two shafts, the main shaft 18 ft. inside diameter, 45 ft. deep, and an upcast shaft 8 ft. inside diameter, 36 ft. deep; both shafts are brick lined and a sump is provided in the main shaft, from which a roadway runs to the upcast shaft, where the second roadway, approximately at right angles to the first, as shown in the key plan (Fig. 2), runs to the exhibition hall, rising slightly towards the end. This arrangement permitted the work to be carried on from three points; the total length opened out is some 400 yards, including the roadways along which reproductions are made of longwall faces. It was necessary to devise a form of construction which could be easily and quickly completed and, while having sufficient strength, should be as inexpensive as possible; for this purpose 6-in. by 4½-in. rolled steel joists have been used for the legs and the roof, and these have been backed with 3-in planks; the floor is of 6-in. concrete, with a short length of rail under each leg to distribute the weight; a section of the main heading is shown in Fig. 3. For the larger span at junctions 8-in. by 5-in. joist is used, and the thickness of the concrete is increased to 2 ft. under the legs, a precaution necessary, with the London clay in which the mine is sunk, to prevent the legs from sinking into the floor.

After the roadways had been connected openings were made for an underground office, pump rooms, hauling engine rooms, heading, driving, and various other mining operations. Five working faces have been arranged, showing different methods of longwall working, the sections of which are given in Figs. 4 to 6. No. 1 face shows a 4 ft. 6 in. seam of coal being worked by hand (Fig. 4); No. 2, a 4 ft. 6 in. seam undercut by a disc cutter and loaded out by hand; No. 3, a 3 ft. seam worked by hand and loaded out by a belt conveyor; No. 4, a 3 ft. seam undercut by a chain-type coal cutter and loaded on a jigging conveyor (Fig. 5); No. 5, a 2 ft. seam undercut by a bar-type coal cutter (Fig. 6) and loaded by a shaker conveyor to a mechanical loader, from which it is delivered direct into the tubs. The seam in each case has been placed near the roof, so that the visitor can see the positions of the miners in hand working and follow the methods of coal-getting by the use of the various coal-cutting machines; he can examine the flitting gear by means of which they haul themselves along and the conveyors used for handling the coal when it has been brought down and for loading it into the tubs.

Coal in large blocks was brought from actual workings in order to make this portion of the exhibit quite realistic, an effect which has been heightened by bringing from the collieries some truck-loads of bind of which pack walls have been built. Several types of haulage are shown: by pony, by electric locomotive, and various methods using ropes.

The exhibit below ground is as complete as that above ground and comprises a stretcher bar hoist and a small portable hoist of types used for hauling tubs up steep brows. In the short heading at the end of No. 2 face a fault has been shown in such manner that it serves to explain the displacement of the strata and the direction of drive that would be taken to strike one of the three supposed seams, of which workings are shown. In other parts of the mine camouflage has been adopted to give the desired appearance, but fortunately for the visitor, the head room in the roadway is great enough for a man of average height to be able to walk upright and examine the exhibits free from the dirt and dust of actual work and without the discomfort caused by walking in ordinary headings where seams of 3 ft. and less are being worked.

ENGINE ROOM.

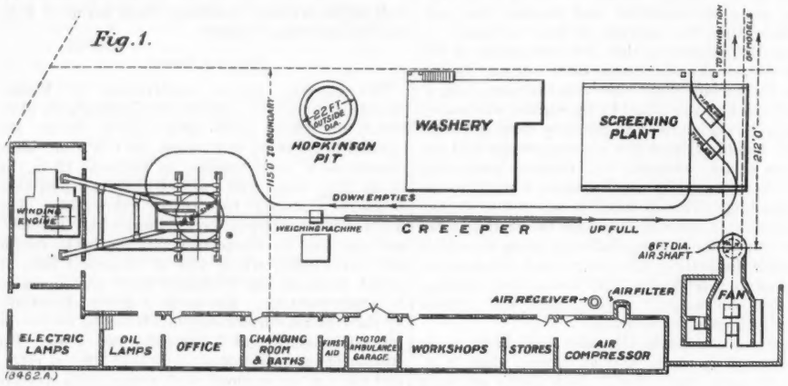
The winding engine, constructed by Messrs. Markham and Co., Limited, of Chesterfield, illustrated on Plates LXV and LXVI, is of the parallel drum type, 10 ft. diam. by 6 ft. 6 in. wide, carried on a shaft running in bearings 12 in. by 24 in. long, fitted with babbitt-lined cast-iron shell bearings arranged for grease lubrication. The drum is fitted with post brakes lined with "Ferodo" and operated by compressed air, the brake engine and overwinder, which will be described later in detail, being of the Whitmore type, also operated by compressed air. The drum is driven electrically by three-phase current supplied from the exhibition generating station at 3,300 volts, 50 cycles. The British Thomson-Houston motor is of 500 h.p. rating and 850 h.p. on overload, with a maximum speed of 470 revolutions per minute in either direction. It is of sufficiently rugged construction to withstand the heavy service of winding duty, and particular attention has been given to the design of the rotor, which has to withstand heavy reversing stresses, the rotor winding and slip-ring gear being subjected to twice the normal rotor volts when using reverse current braking. The motor, shown in plan in Fig. 10, is connected to the reduction gear by means of a Wellmann Bibby flexible coupling; the reducing gear consists of double-helical machine-cut gearing by David Brown and Sons, Limited. Compressed air for operating the brakes and the keps is supplied to a reservoir in the engine room by an Alley and MacLellan air compressor, driven by a 10 h.p. B.T.H. motor. The depth indicator, supplied by the Pepper Mill Brass Foundry Company, Limited, has a dial 4 ft. 6 in. in diameter, with a pointer driven through mitre gears from the drum shaft. The cages (Figs. 11 to 13) are of very large size, 15 ft. 1 in. long by 3 ft. 6 in. wide; they are designed for double decks, but, as the exhibition authorities did not consider it advisable to use double decks, they have been fitted with a temporary timber floor on the bottom deck and the upper deck has not been fitted in place. The design provides for sloping bottoms, and it has been necessary to pack these somewhat in order to obtain a level floor. The cages come to rest at the top of the shaft at keps which are arranged at either end of the cage and are operated by Marson's hydro-pneumatic kep-operating gear, made by Markham's. This gear is shown in front elevation in Fig. 14, at the top of the shaft, and will be described in detail later. The whole of the constructional details of the kep girders and buntings at the pit bottom have also been supplied by Markham's.

BRAKE ENGINE AND OVERWINDER.

It has been found from experience with the earlier types of powerful brakes for winding engines, whether operated by weights or by a steam cylinder, that there is uncertainty as to the amount of brake load applied and a difficulty in graduating the load from a minimum to a maximum. There have been several causes for this: in some gears the action of the fork on the brake lever applies the steam or compressed air to a cylinder, the motion of the piston in which is checked by a cataract or hydraulic dash-pot, but in this case the action of the lever is to operate the control valve—and time of application as well as the extent of valve opening are both factors in the result. In other instances, the position of the foot lever varies with the wear on the brakes over a range from the newly-adjusted

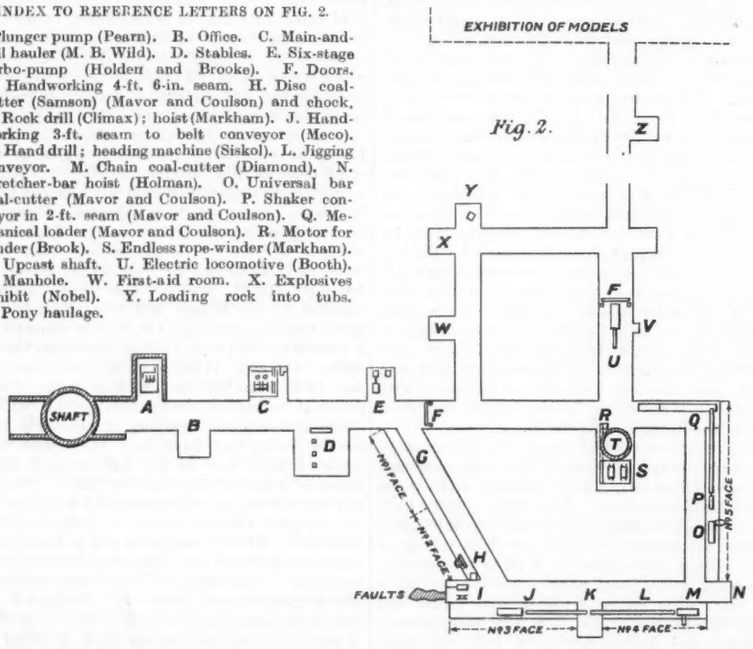
position to that in which adjustment is required. This renders it difficult for the driver to accustom himself to the amount of load he desires to apply. One means of attempting to overcome this difficulty is by the use of two brakes; a foot brake for ordinary light loads and a steam or air brake for use in emergency; the latter has the objection that it may be forgotten at the moment of need, or it may not function properly as a consequence of infrequent use. The Whitmore safety brake has been devised with the object of eliminating these dangers, and it is claimed by the makers that it ensures that any brake load can be applied between maximum and minimum with certainty, and that the load always corresponds to the position of the hand and foot lever. For example, if half-load is applied with the lever half over, in one case, this will remain so for the life of the brake blocks, because an automatic gear acts to take up the wear on the brakes as soon as it has exceeded a small amount. This feature has led to the adoption of the gear in cases of sinking when using the coal winding engine—work of a dangerous character, as men are working under the tub, and it is essential that the brake should be of the most reliable character.

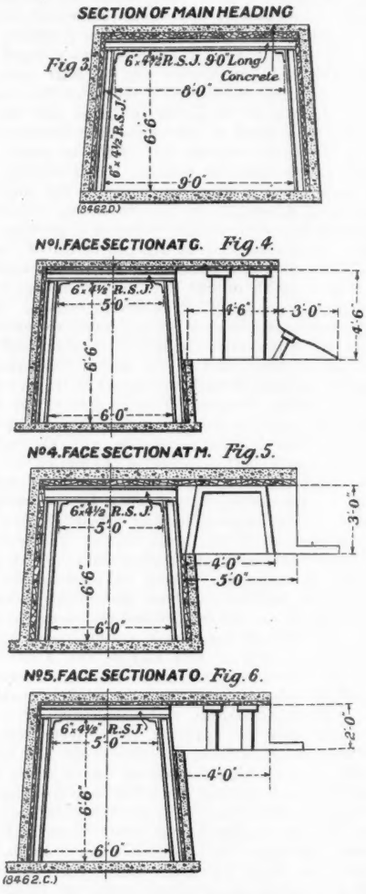
The arrangement and action of the Whitmore brake may be seen by reference to Figs. 8, 9 and 10, Plate LXVI, which show diagrammatically the gear applied to post brakes as fitted in the present instance. The brake engine A, Fig. 8, in this case operated by compressed air, and having a working cylinder 7 in. by 16 in., is fitted with a floating lever gear so arranged that the position of the hand lever is copied by the gear. Weights B are suspended from the continuation of the piston rod C; these weights apply the brake and compressed air supplied to the underside of the piston takes the brakes off. The rod C is threaded through the spring box D which can slide on it. The lower end of the spring box bears on the brake lever E, and the springs contained in the box are compressed between the bottom of the box and a plate, the travel of which on the rod C is limited by a collar on the spindle. Fig. 26, page 679, shows the brake with about half the load applied. The brake lever E connected by H (Fig. 8) to the tops of the posts, brings them together as E descends following the movement of the hand lever, thus allowing the springs to be more and more compressed as the lever E goes over until the distance sleeve inside the box D is reached when the maximum load is applied. In the minimum load position, the collar J on the rod C below the lever E touches the latter. The automatic adjustment is effected as follows: the end of the pull-rod K is threaded and carries a ratchet nut L mounted in the rocking block M of the brake lever. This ratchet nut is actuated by a pawl operated by a rod attached to an extended arm of the lever E. On a downward stroke of the lever E this rod is pushed up, and when the lever E and the rod descend to a certain distance, the pawl will take another tooth; on the return or upward stroke of the lever E, the rod is brought downwards by a lever coming into contact with the collar on the rod, thus screwing up the nut to the permitted extent. The lever E is not forced down to the position that enables the pawl to engage another tooth till the brakes have worn to the extent that permits the gear to operate. The adjustment is so small that there is very little difference in the position of the brake piston immediately before and after each automatic adjustment.



INDEX TO REFERENCE LETTERS ON FIG. 2.

A. Plunger pump (Pearn). B. Office. C. Main-and-tail hauler (M. B. Wild). D. Stables. E. Six-stage turbo-pump (Holden and Brooke). F. Doors. G. Handworking 4-ft. 6-in. seam. H. Disc coal-cutter (Samson) (Mavor and Coulson) and chock. I. Rock drill (Climax); hoist (Markham). J. Handworking 3-ft. seam to belt conveyor (Meco). K. Hand drill; heading machine (Siskol). L. Jigging conveyor. M. Chain coal-cutter (Diamond). N. Stretcher-bar hoist (Holman). O. Universal bar coal-cutter (Mavor and Coulson). P. Shaker conveyor in 2-ft. seam (Mavor and Coulson). Q. Mechanical loader (Mavor and Coulson). R. Motor for winder (Brook). S. Endless rope-winder (Markham). T. Upcast shaft. U. Electric locomotive (Booth). V. Manhole. W. First-aid room. X. Explosives exhibit (Nobel). Y. Loading rock into tubs. Z. Pony haulage.





Overwinding Prevention Gear.

The great danger arising from overwinding and the accidents produced thereby have caused such serious consideration to be given to this risk by mining engineers and mine inspectors that it is probable that the necessity for a safety device will become more appreciated in the future than it has been hitherto. The object of the device is to take the control out of the driver's hands should he make any slip liable to cause an accident, such, for instance, as

(*a*) Starting the engine in the wrong direction so as to wind up the top cage;

(*b*) Failure to cut off the power at the right moment, and thus to finish the wind at a speed above the usual, causing an overwind.

The Whitmore overwinder is arranged to deal with the first cause of overwinding by rapidly cutting off the power and quickly applying the brakes if a cage or skip should rise above a predetermined point. The latter case is provided for by arranging that if at a given point in the wind the driver has not shut off this power, or if through running a light load, he has exceeded a pre-determined speed, the overwinding gear acts automatically, cutting off the power and applying the brakes gradually until the cage is pulled up at a point before it reaches the end of the wind.

The overwinder comprises two screws R and S, Fig. 24, representing the wind of each rope. When there are two ropes on one drum the screws are both driven from the drum. Where there are double drums, with one rope on each, the screws are driven separately, each from its particular drum. A governor is also fitted, combined, and mounted on the same column as the screws; it may

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page 677.*)

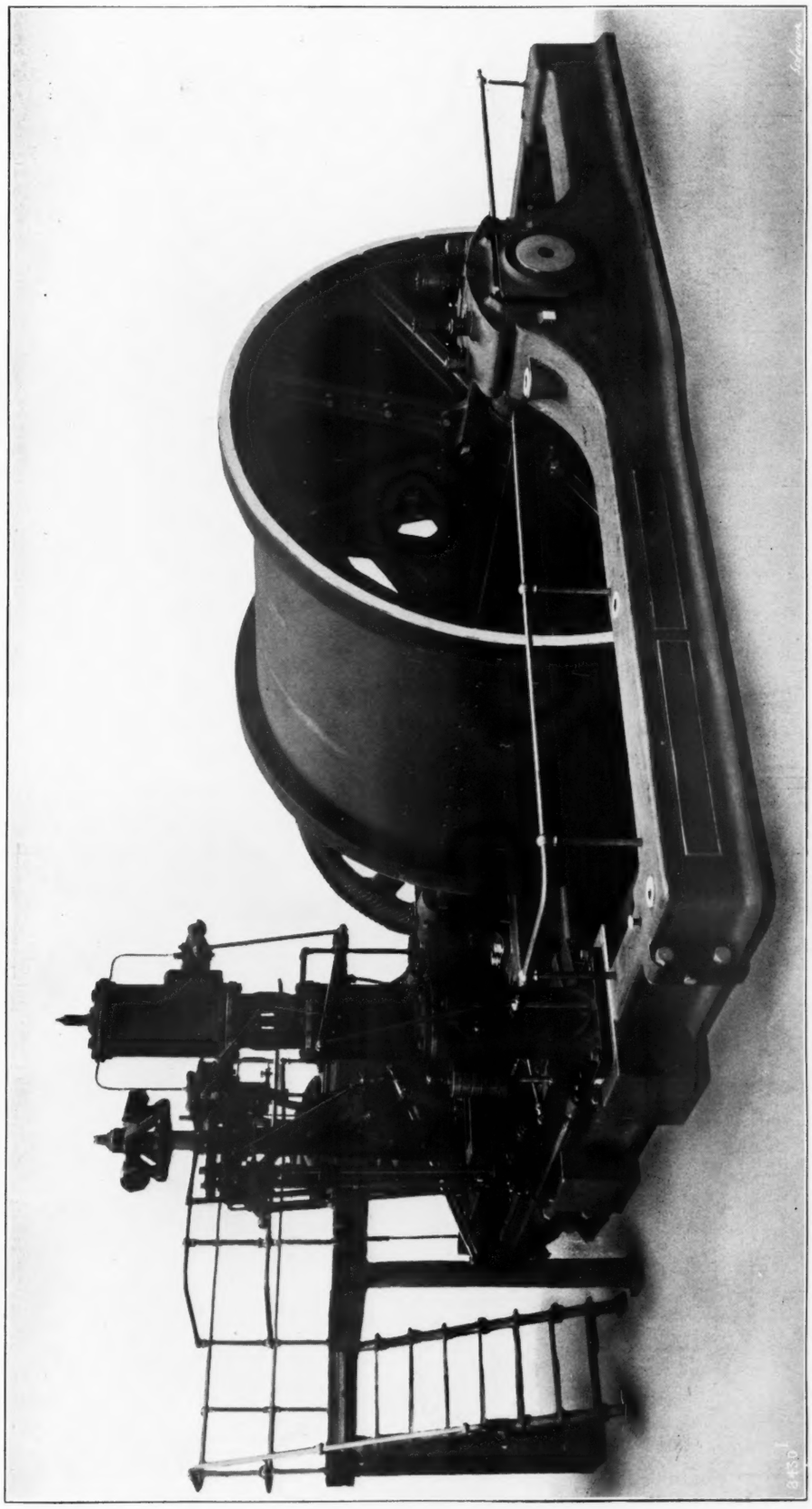


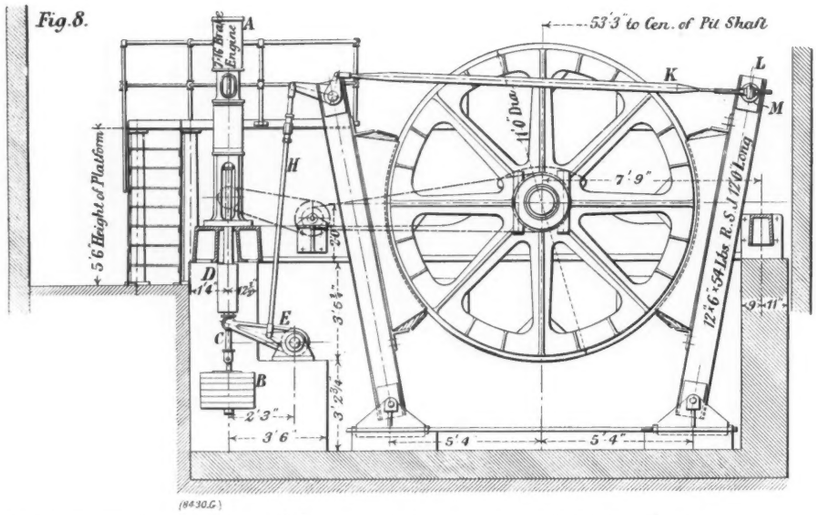
FIG. 7. MARKHAM WINDING ENGINE WITH BRAKE ENGINE AND WHITMORE SAFETY GEAR.

(*To face page 678.*)

THE COLLIERY AT THE BRITISH

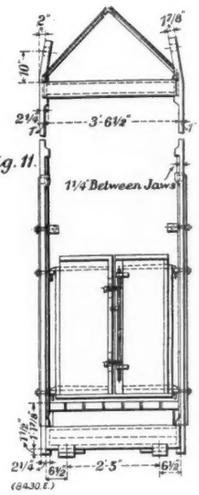
(For Description see Page 677.)

Fig. 8.



(8430.G.)

Fig. 11.



(8430.E.)

Fig. 9.

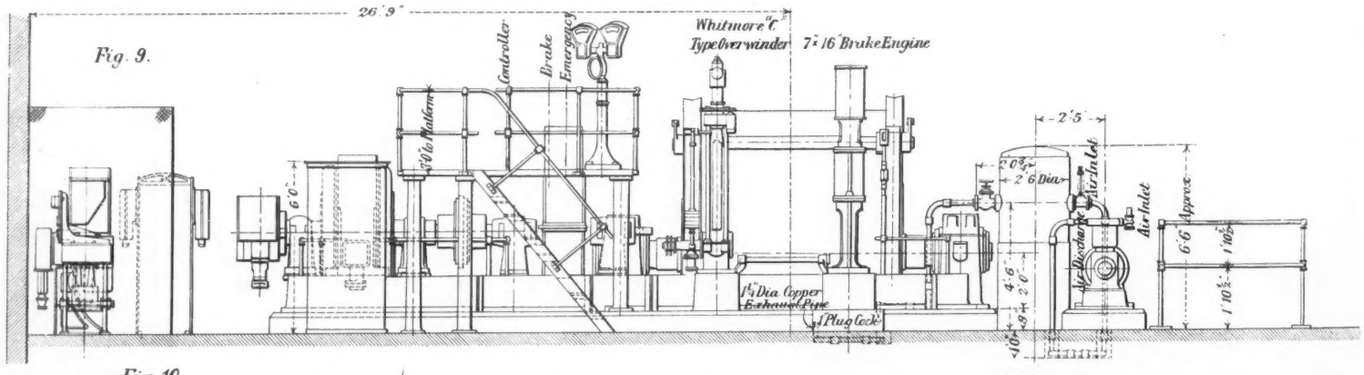
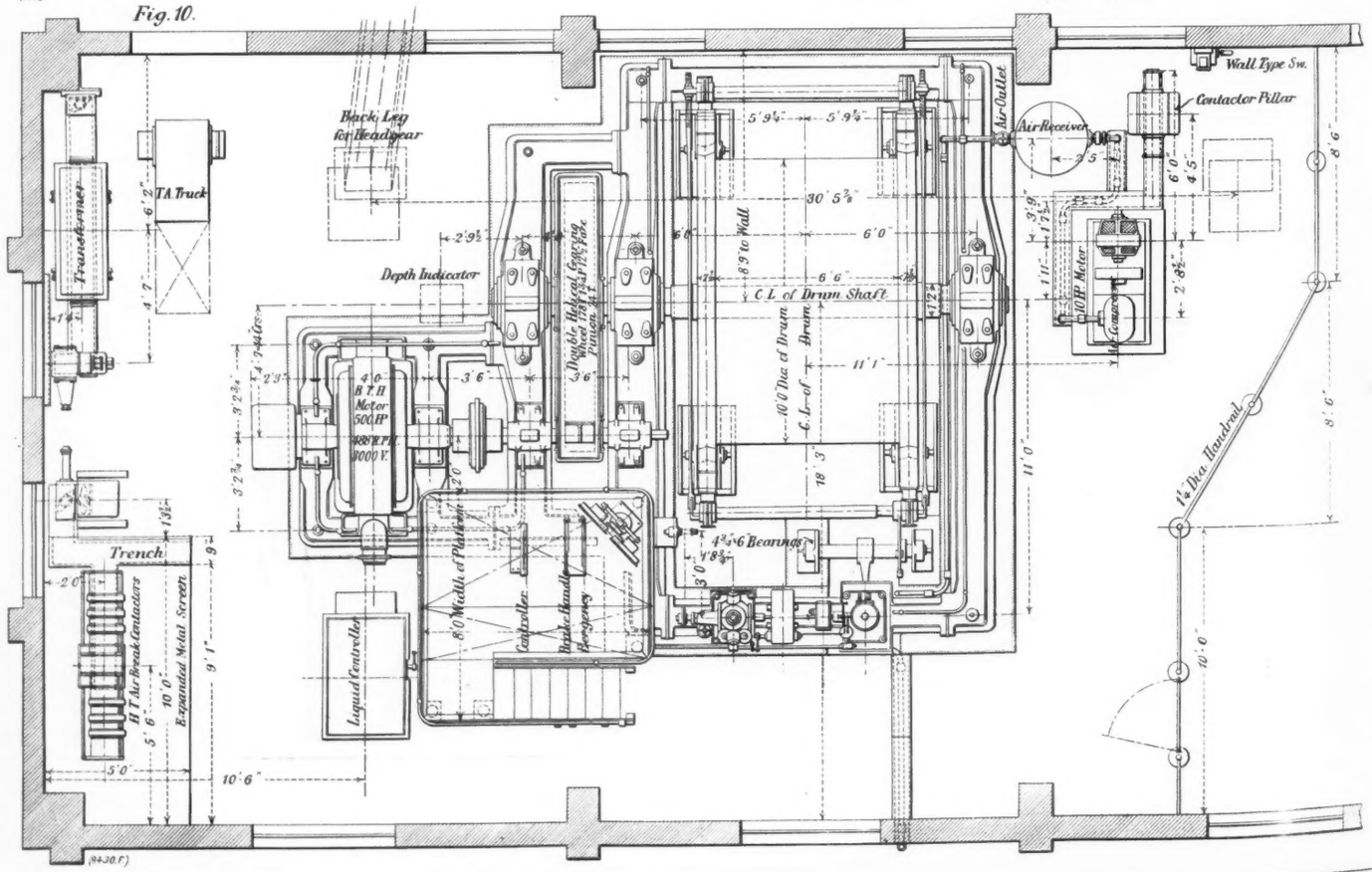


Fig. 10.



(8430.F.)

IE BRITISH EMPIRE EXHIBITION.

or Description see Page 677.)

Fig. 12.

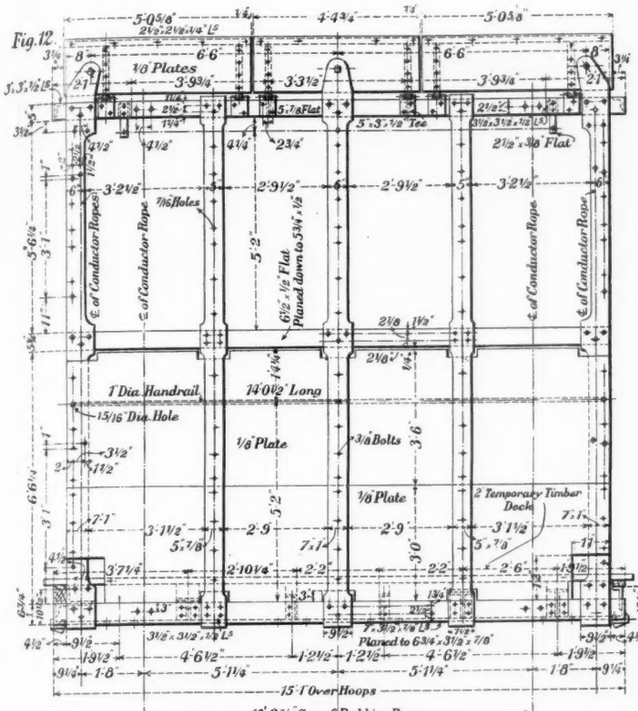


Fig. 13.

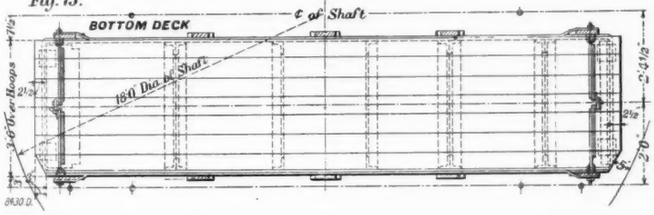
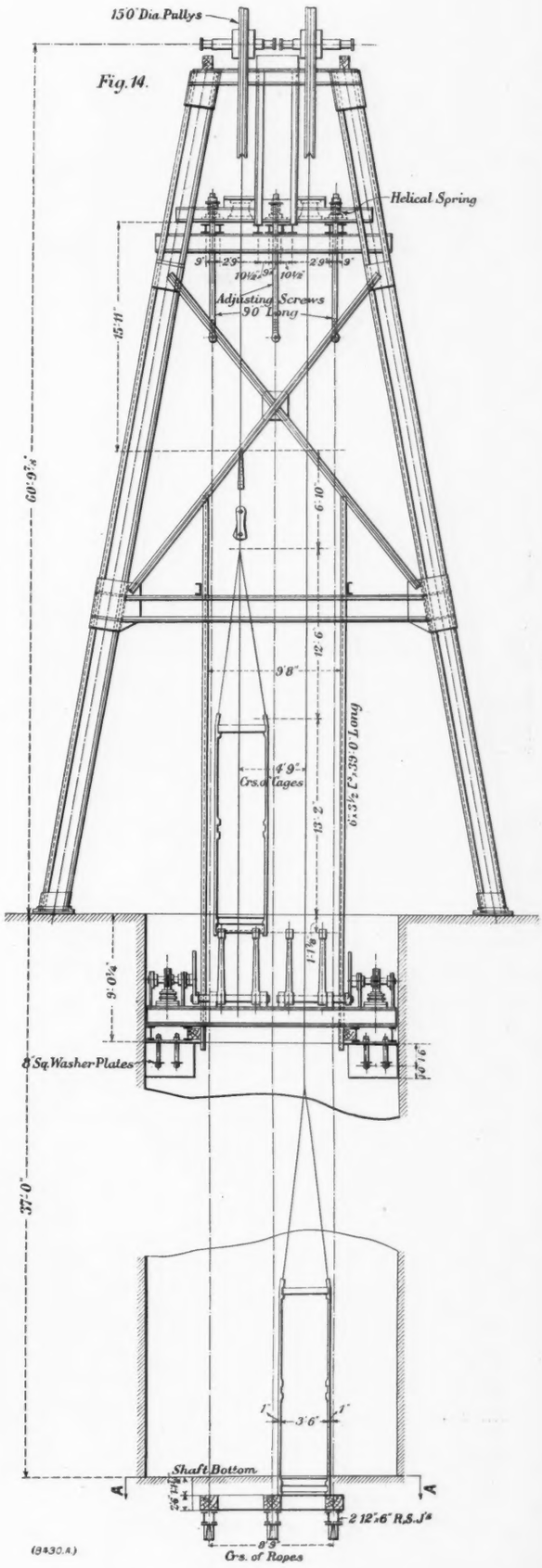


Fig. 14.



(8430.A.)

PLAN ON LINE A.A. (Fig. 14)

Fig. 15.

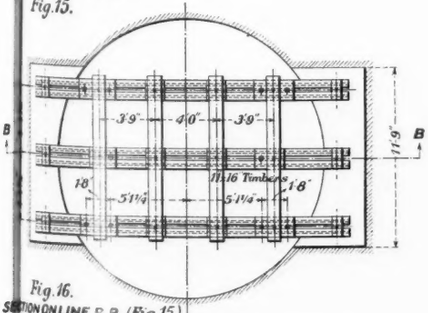


Fig. 16.

SECTION ON LINE B.B. (Fig. 15)

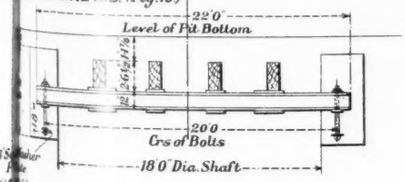
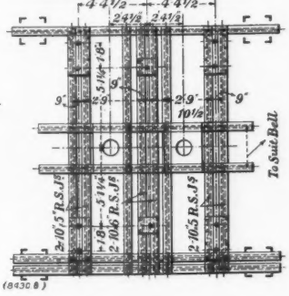


Fig. 17.

PLAN AT CONDUCTOR LEVEL SHEWING ARRANGEMENT OF GIRDERS



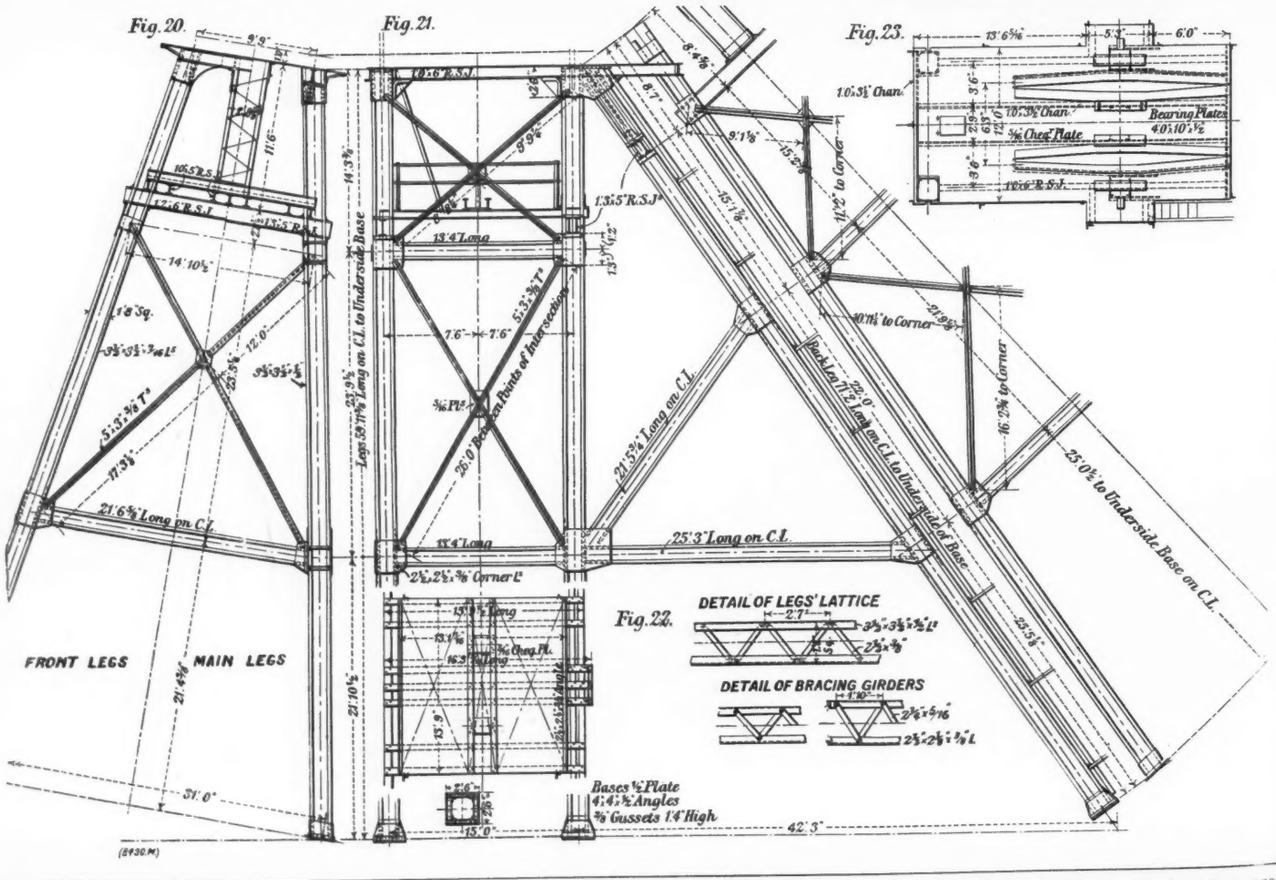
(8430.B.)

HEAD GEAR FOR THE COLLIERY; BRITISH EMPIRE EXHIBITION.

(*For Description, see Page 677.*)

FIG. 18.

FIG. 19.

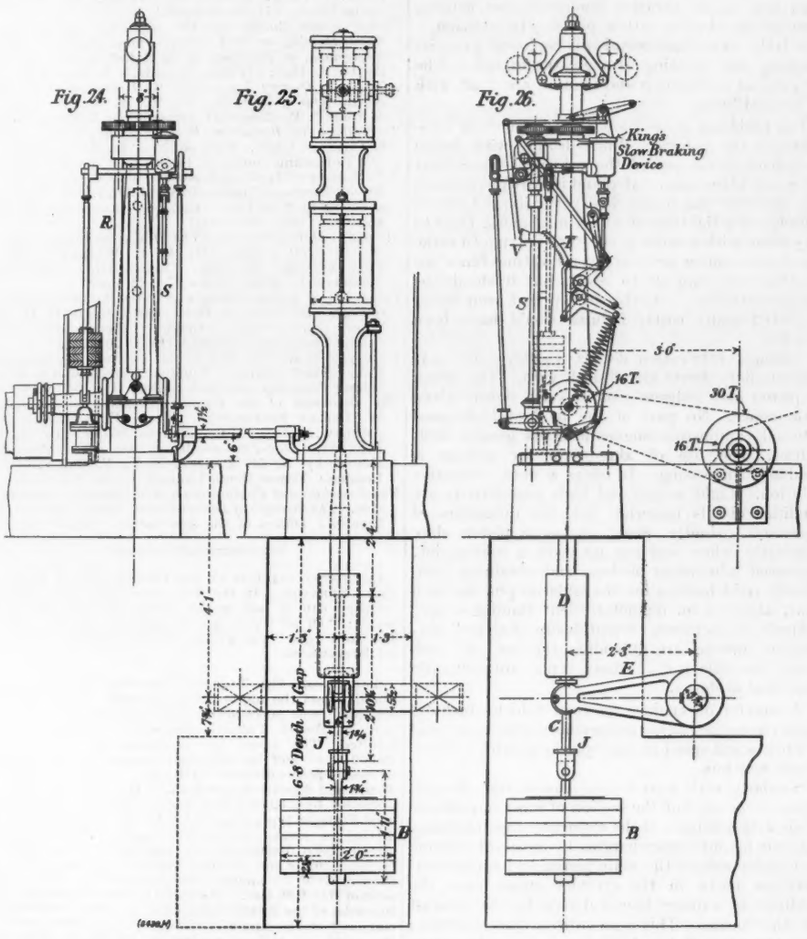


(*To face Page 679.*)

or may not be arranged to control the cut-off of the power, but in any event it is arranged to control the overspeed portion of the safety mechanism. The governor is of the parallel ball type, compressing a spring, adjustable to suit the conditions of the particular winding engine. It usually has definite positions for a speed between the maximum speed of winding (60 to 80 r.p.m. of the drum) to a gradual slowing down to 5 per cent. of the normal speed for the last two turns of the drum at the end of the wind. Each of the screws is fitted with two index nuts, the bottom or wing nut forming the first attachment, and the top nut the second attachment. The screws R and S correspond to the respective left- and right-hand cages, and the travel of the nuts up and down the screws gives exact reductions of the wind of each cage. Each nut ascends the screw corresponding to its respective cage, and after the cage has travelled a distance, say one-half to two-thirds of the wind, the wing nut comes level with the speed hook T into which the wing nut will engage if the driver has omitted to cut off power before reaching this point. The speed hook shown in Fig. 26 is made to a special sweep and directly controlled by the governor, so that if from failure of current (or of steam pressure in a steam plant) or if an extra heavily loaded cage should cause running below the normal speed, the second or third catch will engage with the wing nut. As soon as the wing nut has engaged the hook, the overwinder comes into action, and first trips the cut-out through a special trip gear, cutting off the power and applying the brake gradually, entirely independent of the driver. The action is fully automatic, and should the driver faint or die while the engine is running, the cage will come to rest three or four turns of the screw before the pit bank, without jerk or undue stress on the rope or drum shaft. Enough power is provided in the brake engine to pull up the winding engine should the power not be cut off through failure of the intermediate gear.

In the event of the driver slowing his engine too early, and then putting on too much power to get to bank, a third attachment V is provided which consists of a series of fine catches and a steel pawl that can only engage at any point when the drum is in its two final turns of the wind. If the driver then has too much speed, this attachment causes a spring-loaded trigger to be released; the spring is sufficiently strong to put the brake engine on suddenly enough with full power, so that the drum is always pulled up in less than one revolution, and before pit bank is reached. This attachment is operated by the governor, but at a slow speed of the drum; in practice the governor is given free lift, that is, without spring compression, so as to make its action very sensitive. The great feature of this attachment is the safeguard it affords when lowering men, because at the reduced speed usual for lowering men on deep winds, it is possible to miss the speed hooks which are usually set for the maximum speed of coal winding. On the arrival of the cage at bank, the second attachment or top nut comes into contact with a fixed nut which causes a quick action to trip the spring catch, so that in the event of the driver forgetting to reverse the engine and travelling too far in the upward position, the power is cut off and the brakes are fully applied. In actual practice, with an allowance of 2 ft., a rise of another 6 in. causes the gear to come into action and pull up the engine before the cage has risen another foot. The top nut trips a lever, termed the bridle, clear of a cam in the upward movement, so that the spring catch cannot be jerked out of position when the cage is travelling fast at the middle of the wind. Further, in the case of what is termed "half an overwind," when the catch is only partly pulled out, the cage on returning to its normal position, allows the bridle to wedge itself into its correct position in full engagement with the catch.

On pits in which double or treble decking is in use, a fourth attachment is fitted, which comes into action thus: The cage ascends to its top position, and then is lowered to the second position. Should the driver on starting again make a mistake, and if, instead of lowering, he should raise the cage with full power on, the spring trigger will be released and the cage brought to rest before it has returned to the top position. In the case of cages that have been converted into double deckers there is a diminution of clearance between the top position and that at which the safety detaching hook comes into action. This gear ensures the drum being brought to rest before the cage reaches this extreme position. It has been found possible to fit this gear where the total clearance between these two positions has amounted to 3 ft. only. When the overwinder has been brought into action, it can be reset by the driver, using a 3-ft. long lever, with re-engagement of the power control levers and the spring catch at one operation, occupying a few seconds only. Usually the brake engine and the overwinder are mounted side by side on self-contained cross channels, so that all the levers and connections are visible to the attendant for oiling and cleaning, as in the present case.



HEAD GEAR.

The type and design of colliery headgear depends upon several conditions, the chief amongst which are the size of the cages, the number of decks, the number of cages, the depth of the mine, and the amount of coal raised per hour. The structure has two distinct functions to perform, the guiding of the cages to bank, and resisting the resultant force due to the loads on the vertical and inclined portions of the ropes. These loads comprise the cage (a dead load) and also the working loads due to positive or negative acceleration in winding or braking. In deep shafts, this may be substantially increased by the weight of the rope itself unless a balance rope is used. For the small depth of the mine at Wembley, these circumstances could have no influence, and the design adopted has been that of a gear suitable for an actual colliery, several hundred yards deep, for which it will ultimately be used.

The part of the structure immediately over the pit, that is, the tower or shaft framing, carries the continuation of the guides, In some cases this is almost an independent structure, connected at the top to the main legs; but, frequently, as in the present instance, the whole forms a single steel structure in which the front, main and rear legs are of lattice work and are braced together by diagonals. The inclination of the rear legs in relation to the direction of the resultant force varies according to the practice of the country, or even of the coalfield. In France, it is common for the back legs to be arranged at nearly the angle of the resultant and to take practically the whole load. In England, it is more usual to divide this over the main and back legs, the one being nearly vertical, and the other having nearly the mean inclination of the two winding ropes. It is the latter form that has been adopted in the present instance.

The headgear, which was constructed by the Norton-Harty Engineering Company, Limited, is shown in elevation and detail in Figs. 14 and 17, Plate LXVI, and Figs. 20 to 23, Plate LXVII; general views are given in Figs. 18 and 19, Plate LXVII. The structure is 60 ft. high to the centres of the pulleys, and is fitted with a pulley lifting frame. The general construction consists of $3\frac{1}{2}$ in. by $3\frac{1}{2}$-in. steel angles, the thickness being $\frac{7}{16}$ in. for the front legs and $\frac{1}{2}$ in. for the main and back legs. The principal members are braced well together with $2\frac{1}{2}$-in. by $\frac{5}{16}$-in. lattice bars, and the joints in the legs are provided with $\frac{3}{8}$-in. cover plates, the interior being reinforced by cover angles. Each leg is provided with a foot 2 ft. 6 in. sq. of $\frac{1}{2}$-in. plate secured to the leg by $\frac{7}{16}$-in. gusset plates and 4 in. by 4 in. by $\frac{1}{2}$-in. angles. The bracing girders consist of $2\frac{1}{2}$-in. by $2\frac{1}{2}$-in. angles braced with $2\frac{1}{2}$-in. by $\frac{5}{16}$-in. flat lattice bars, large plate and angle gusset brackets

connecting the girders to the legs. The size of rivets generally is $\frac{3}{4}$ in., except in the bracing girders and platforms where $\frac{5}{8}$-in. rivets are used. Detaching bells for receiving the safety hooks (which will be described later), in the event of an overwind, are carried on a substantial frame of rolled steel joists 14 in. by 6 in. transversely, and 10 in. deep, by 5 in. and 6-in. wide, in the direction of the plane of the pulleys, as shown in Fig. 17, Plate LXVI. The diagonal bracing is of 5-in. by 3-in. by $\frac{3}{8}$-in. steel, tee section riveted to the leg connections, as shown in Figs. 20 and 21, Plate LXVII. There is a top platform of chequer plates, stiffened and riveted to the platform girders. Bearing plates, $\frac{1}{2}$-in. thick, are provided for carrying the pedestal stools. A stairway 15 in. wide, with 4-in. by 2-in. channel stringers and chequer plate steps, is secured to one of the back legs with appropriate tube handrailing. The pulley sheaves are 15 ft. in diameter or 144 times the diameter of the rope. The usual minimum ratio for the respective diameters of sheave and rope is 100 to 1.

(To be continued.)

LITERATURE.

The Internal-Combustion Engine. Vol. II.—High-Speed Engines. By Harry R. Ricardo, B.A., A.M.Inst.C.E., B.I.A.E. London: Messrs. Blackie and Son, Limited. [Price 30*s.* net.]

IN no branch of engineering have more rapid strides been made within the last few years than in the development of the high-speed internal-combustion engine, and unquestionably, if the late war and the necessity of meeting its intensive demand for engineering material left a deeper, more lasting and more useful imprint in one branch of commercial engineering than upon another, it was undoubtedly in the department which forms the subject of the volume under review. Truly it may be stated that so perfect has this machine become, resulting from the enormous wealth of available results of research and investigation, that a study of the design will enable performance to be gauged or conversely designs to be prepared which will accurately meet specific requirements.

In this particular realm of work the author is an acknowledged authority, backed by almost unique facilities for the promulgation of important researches more particularly in the question of the properties of various volatile liquid fuels upon which such engines depend. The facts elucidated by the studies of Ricardo and Tizard will come as somewhat of a surprise to many. With highly forced engines such as aero engines for war purposes, the realisation of the maximum continuous output of power from a limited size and mass of engine was a national problem of the greatest magnitude, and the limits imposed by the quality of fuel, compression ratios and detonation gradually emerged as definite laws. Much useful information is given on these subjects, showing incidentally the advantage of using alcohol as a fuel in a suitably designed engine. It is well that the results of these researches should be put on record, because although the principle *raison d'être* of their inception is no longer present, and the importance of their applications to ordinary commercial work is somewhat limited as yet, it is quite impossible to forecast the trend of the future, when it is more than likely that these considerations will again have force possibly in a commercial sense.

The first three of the 12 chapters deal with the more scientific and specialised side of design. The remaining nine have much force where everyday commercial design and production are concerned, and so, at the moment, are of the more general interest. It is becoming increasingly acknowledged, in practice in all spheres of internal combustion, that the actual form of the combustion chamber is of vital importance. Ricardo illustrates all the forms which have been developed, showing the importance of maintaining the turbulence of the entering gases, the position of the ignition plug, the avoidance of any pockets where the gas may become stagnant, and the free entry for the gases after passing the inlet valve. A very interesting table is given illustrating these points. The relative power output varies from 75 per cent. to 100 per cent. The latter figure is achieved by the best design, in respect of the factors mentioned, irrespective of cost or complication, and the former with the least cost. Compromises are often imperative in the design of engineering productions, yet it is shown that with a simple design 90 per cent. output can be achieved without complication or great expense so long as the first principles are adhered to.

The subjects of lubrication and bearing-wear are treated in a thoroughly practical manner. We agree with the author that for the class of work under discussion the white metal of the bearings should not be too hard, in order that particles of grit shall be embedded in the white metal rather than act as an abrasive compound, so causing wear of the shaft or other parts. In addition, a relatively soft white metal will be found to resist cracking and splitting to a greater extent. The subjects of carburation and ignition are dealt with on normal lines.

The problems of mechanical design occupy two-thirds of the volume. When dealing with design in general terms one of the principles enunciated has never better been stated and is worth repetition: "It is better far to use 500 parts if need be, to comply with the laws of sound mechanics, than to defy them with a single part. The craving to make one single member perform several distinct functions is often very difficult to resist, but it should be firmly controlled." If this axiom had been better respected many costly failures would have been avoided.

Bearings, lubrication details, valves, valve gear and auxiliary drives are all dealt with. The design of piston and gudgeon pins is very rightly given prominence. No part of the modern high-speed internal combustion engine presents greater difficulties. The use of aluminium for pistons is gradually increasing. It offers a most attractive solution. Light weight and high conductivity are qualities of this material, yet the difficulties of increased cylinder wear, excessive piston slap, especially when starting up with a cold engine, increased lubricating oil loss, and obtaining sufficiently rigid holding for the gudgeon pin, are such that, above 3 in. diameter, silent running is very difficult to achieve. Scientifically designed aluminium pistons are extending the use of such alloys for this part. Many types are critically described in detail.

A chapter on engines for road vehicles includes basis curves for engine performance relative to road gradients and speed in miles per hour using a three-speed gear-box.

Similarly with aero engines, interesting descriptions are given, but the section of most importance deals with a subject of the moment—supercharging. Ricardo favours supercharging by means of utilising the under side of the main piston and supplementary air ports in the cylinder rather than the addition of a rotary blower driven by the exhaust or other means. This is an entirely open question; but the general trend to-day is towards supercharging utilising a blower.

The last chapter in the book deals with high-speed heavy duty engines for tanks. Many of these machines of war were propelled by Ricardo engines, and this forms perhaps the most interesting chapter, since the author is in a position to give the leading considerations of the design, details of construction, data of performance both technically and regarding wear and tear and reliability, indicating the various stages in the evolution of a series of engines and the changes made from time to time.

The volume concludes with a good index. It will be admitted that there are too many text-books on most of the great engineering subjects, and there remains only place for those by experts of wide experience. This book has given us much pleasure, not only for the wealth of experience of research and actual practice fully revealed, but for the clarity of the language used. It will readily find a high place in the world of engineering literature and is worthy, on revision in the future, of careful expansion.

BOOKS RECEIVED.

Drying by Means of Air and Steam. By E. HAUSBRAND. Translated from the German by A. C. WRIGHT, M.A., B.Sc. Third revised English edition. London: Scott, Greenwood and Son. [Price 6*s.* net.]

Principles of Industrial Welfare. By JOHN LEE, C.B.E., M.A. London: Sir Isaac Pitman and Sons, Limited. [Price 6*s.* net.]

Payment by Results. Introduction, Organisation, Rate-Fixing. By J. E. POWELL. London: Longmans, Green and Co. [Price 21*s.* net.]

Road Engineering. By E. L. LEEMING, M.Sc. London: Constable and Co., Limited. [Price 18*s.* net.]

Buildings of To-day and To-morrow. London: Trollope and Colls, Limited.

The Indian Forest Records. Vol. X, Part VII. Interim Report on the Work under Projects No. 1 *and No.* 0, *by the Section of Timber Testing, including the Results of the Mechanical and Physical Tests on certain of the commoner Indian Timbers up to end of* 1922. By L. N. SEAMEN, M.A., B.Sc. Delhi: Government Central Press. [Price 9 annas.]

United States Bureau of Mines. Bulletin No. 225. *Stone Dusting or Rock Dusting to prevent Coal Dust Explosions, as practised in Great Britain and France.* By G. S. Rice. [Price 10 cents.] Technical Paper No. 353. *Quarry Accidents in the United States, during the calendar year* 1922. By W. W. ADAMS. [Price 10 cents.] Washington: Government Printing Office.

A Textbook of Petroleum Production Engineering. By L. CHARLES UREN. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 30*s.* net.]

A Dictionary of Applied Chemistry. Vol. V. Oxygen-Rye. By SIR EDWARD THORPE, C.B., LL.D., F.R.S. Revised and enlarged edition. London: Longmans, Green and Co. [Price 60*s.* net.]

Management Engineering. The Design and Organisation of Industrial Plants. By P. F. WALKER, M.M.E. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 17*s.* 6*d.* net.]

Principles of Electroplating and Electroforming (Electrotyping). By WILLIAM BLUM and GEORGE B. HOGABOOM. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 20*s.* net.]

Principles of Electric Motors and Control. By GORDON FOX. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 17*s.* 6*d.* net.]

The Resources of the Empire. Communications. By W. TETLEY STEPHENSON. *Fuel.* Edited by G. W. ANDREW, M.Sc., F.I.C. *Ferrous Metals.* By M. S. BIRKETT. *Non-Ferrous Metals and other Minerals.* Edited by N. M. PENZER, M.A., F.G.S., F.R.G.S. London: Ernest Benn, Limited. [Price 21*s.* each.]

The Association of Engineering and Shipbuilding Draughtsmen. The Strength of Dished Ends. By C. C. POUNDER. London: Offices of the Association. [Price 2*s.*]

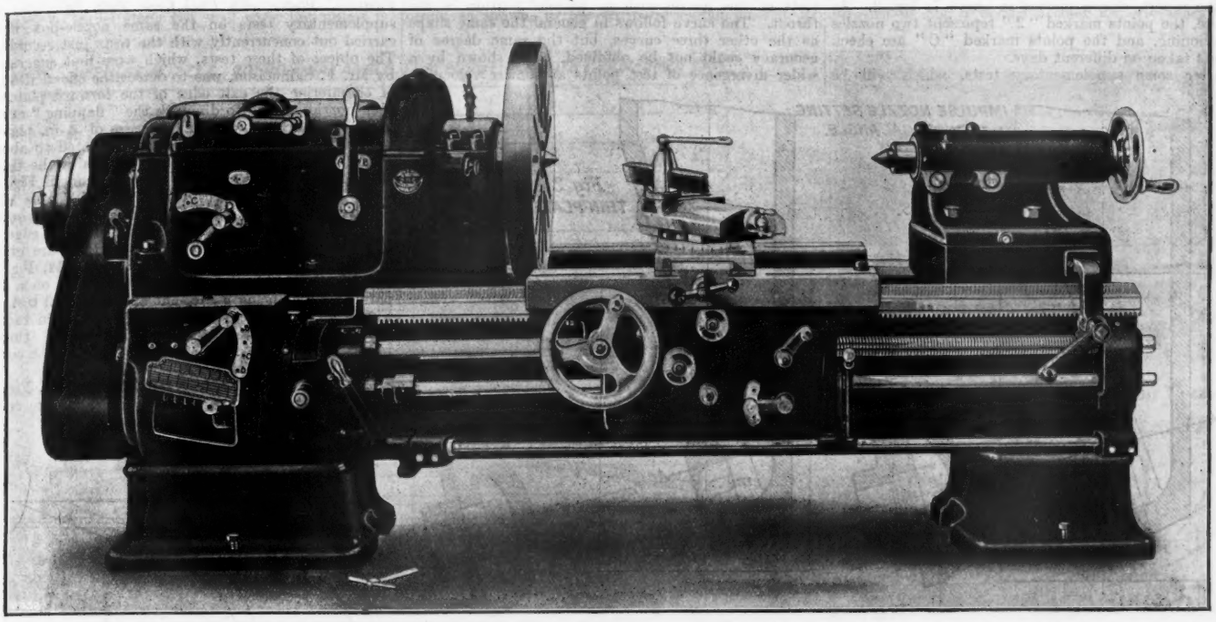
CHEMISTRY AND GAS AT THE BRITISH EMPIRE EXHIBITION—ERRATUM.—In the first paragraph of our article on page 646 of last week's issue, the third sentence began: "Of all these, gas occupies the largest area." The word "gas" was wrong; the food division occupies the largest area.

THE MOTOR OIL TANKER "BRITISH AVIATOR."—On Tuesday last the motor-driven oil-tank vessel "British Aviator" was successfully launched from the Jarrow yard of Messrs. Palmers Shipbuilding and Iron Co., Limited. The vessel has a deadweight capacity of 10,000 tons, and her principal dimensions are: length between perpendiculars, 440 ft.; extreme breadth, 57 ft.; and depth to upper deck, 33 ft. 11 in. She will be propelled by a 3,000 b.h.p. Diesel engine of the Camel-laird-Fullagar type, constructed by Messrs. Palmers, and driving a single screw. The engine, however, has already been illustrated and described in ENGINEERING on page 265 of our previous volume, and the results of shop trials of the engine were given on page 409 of our issue of March 28 last. The vessel has been constructed to the order of the British Tanker Co., Limited, a subsidiary company of the Anglo-Persian Oil Co., Limited, and is the ninth oil tanker constructed by Messrs. Palmers for that firm. It is, however, the first vessel of the British Tanker Company's fleet to employ internal-combustion engines for propulsion.

THE LATE MR. T. O. NIVEN.—A prominent engineer and one who took a large part in railway construction in Scotland, died at his residence, 65, Ann Street, Hillhead, Glasgow, on May 4, in his 81st year. He received his engineering training in Glasgow University under Professor Macquorn Rankine, and served articles in the office of Messrs. Formans and McCall. He later acted as resident engineer on the Greenock and Ayrshire Railway and other of the important works of the firm. Mr. Niven located the West Highland Railway from Craigendoran to Crianlarich before it was embodied in the larger scheme, undertaken by Messrs. Formans and McCall. He began business on his own account in Glasgow in 1875, but was subsequently joined by Mr. Andrew Aitken Haddin when the firm became Niven and Haddin. Among the projects he carried through may be mentioned the Kilmarnock, Lockerbie, Millport, Lanark and Milnathort Water Works and the Vale of Leven, Milngavie and Milnathort Sewage Disposal Works. His services were frequently sought in arbitrations relating to Engineering contracts. Mr. Niven must be given credit for his early utilisation of reinforced concrete for water storage purposes in the West of Scotland. Prior to its being taken over by the Caledonian Railway Company, he acted as Engineer to the Wemyss Bay Railway. He was elected M.Inst.C.E. in 1889.

15-IN. GEARED HEAD LATHE.

CONSTRUCTED BY THE CINCINNATI LATHE AND TOOL COMPANY, OAKLEY, CINCINNATI, O., U.S.A.



15-IN. GEARED HEAD LATHE.

IN the illustration above a general view is reproduced of a geared head lathe recently designed by the Cincinnati Lathe and Tool Company, of Oakley, Cincinnati, O., U.S.A. It is a machine of 15-in. height of centres, but others of the same type are made in sizes ranging from 8-in. to 15-in. centres inclusive. The motor from which the drive is obtained may be either mounted above the head or at the back of the lathe. In the first case it is set as low as possible in order to ensure that the centre of the motor is as near the centre of gravity of the lathe as can be arranged. When the motor is placed at the back of the lathe it is bolted to the cabinet leg and placed near the floor line and underneath the overhanging part of the head. Both designs were prepared to give the most evenly balanced combination possible, and as the lathe and motor forms a self-contained unit, it may be set up in the workshop in any position.

For the twelve speeds only thirteen gear wheels are used, and these are entirely enclosed within the head and are lubricated on the splash system. In the process oil is sent to every bearing, no matter what may be the lathe speed, and an indicator gives information of the amount of oil within the bath inside the head. Speeds of working, ranging from 9 to 325 r.p.m., are obtainable, the changes being in geometrical progression. The spindle control lever at the right-hand end of the apron or the lever at the headstock end are used to stop and start the lathe at will. For variable feeding or alteration to suit a change in the pitch of the thread in screw cutting a quickly-operated gear gives 32 different combinations by simply shifting two hand levers.

The interior of the headstock may be inspected at any time through an opening at the top of the cover and without the necessity for removing the entire cover from the head. Large bronze headstock bearings are provided, and may also be adjusted without removing the cover. For use when chucks or face plates are to be removed a plunger is used to lock the gear. The clutch is made integral with the head and the pulley on it is supported as to give no overhung strain on the driving shaft. An oil reservoir is situated between the two brass bushes and ensures effective lubrication when the pulley is running idle.

The actual dimensions to the centre of the lathe shown is 15½ in. from the top of the bed with 21 in. swing over the slide. The motor fitted is of 10 h.p. and runs at 1,200 r.p.m. A complete equipment is provided with the machine.

MAP OF SOUTH AND CENTRAL AFRICA.—With its issue of the 9th inst., the journal *South Africa* has published as a supplement a new edition of its large coloured map of South and Central Africa, showing the railway system and all outstanding characteristics very distinctly.

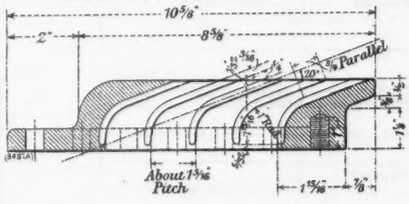
THIRD REPORT OF THE STEAM-NOZZLES RESEARCH COMMITTEE.*

SUMMARY OF PREVIOUS REPORTS.

THE First Report of the Committee was published, without discussion, in Proceedings No. 1, 1923 (pages 1–22).† It contained, amongst other matter, a brief record of the formation and constitution of the Committee, and a complete description in detail of the specially designed apparatus which is still being used for the tests to be described in this report.

The Second Report of the Committee was presented to the Institution on March 16, 1923, at an ordinary meeting and published, together with the discussions in London and in Manchester, in the Proceedings for March, 1923 (pages 311–395).‡ Curves in this report

Fig. 1. IMPULSE NOZZLE-BOX, NOZZLE 2" HIGH. ANGLE 20°; PLATES 3/16 INCH.



showed the relation between the velocity coefficient (ϕ) and the theoretical steam speed (c) for:—(*a*) 1-in. standard Parsons 480 B nozzles with 20 deg. nominal angle; (*b*) convergent impulse nozzles with 20 deg. nominal angle and thin partition plates.

Four separate curves were obtained with this type of nozzle in which the length of parallel portion subsequent to the throat was successively reduced from 3/1 to 2/1, to 1/1 and lastly to 0/1, when compared to the width of the throat itself. The report showed in detail the methods of test and of test calculations, which are still followed, and contained an analysis of the probable accuracy of the results. It was shown on page 323 of the Second Report that at very low steam velocities (300–450 ft. per second) the mean curve through a series of test points may be taken as accurate to ± 1 per cent. As the steam speed increases this degree of accuracy becomes ± 0·5 per cent. at medium velocities (1,000–1,200 ft. per second) and ± 0·4 per cent. at the highest velocities reached in these tests (2,000–2,300 ft. per second). The range of steam speed (300 to 2,300 ft. per second) covered by these curves is considerably greater than has previously been obtained in one apparatus, and all five curves have one marked characteristic, namely, an upward sweep towards the lowest velocities of the tests.

Scope of Work covered by the Present Report.—In the present report will be found all the tests on the convergent impulse nozzles, 20 deg. nominal angle, with thick partition plates. These tests represent, with additions, Item 2 (*b*) of the original programme drawn up on page 20 of the First Report and were carried out on the nozzle-box made at that time. The nozzle-box is shown in Fig. 7 on page 19 of the First Report, and is reproduced as Fig. 1 in this report. In addition a series of tests was devised to determine the effect of chamfer on the exit edges of comparatively thick plates and the above nozzle-box was used for this purpose.

This report also includes the work on ⅜-in. Parsons standard 430 B blades, which emphasises the effect of entry on nozzle efficiency; and the first test results of a set of straight elementary nozzles which were designed by Professor A. L. Mellanby.

TEST RESULTS.

Impulse Nozzles, 20 deg. Nominal Angle, Thick Partition Plates.—The nozzle-box used for all the following tests is shown in Fig. 1, and the original nozzle dimensions are given on page 348 of the Second Report. It will be noted from this figure that the ratio of parallel portion to throat opening is ⅜ in. to ⅛ in., or 3 to 1, which are similar dimensions to those used when the thin-plate nozzles were first tested. In fact, the only difference between the two nozzle-boxes (shown in Figs. 6 and 7 of the First Report*) with the exception of manufacturing irregularities, is in the thickness of the partition plates, the thin plates having a mean thickness of 0·04 in., whereas the present plates are 3/16-in. thick. The setting of these two nozzle-boxes in the tester was also similar, as can be seen from Fig. 2, which shows that, except for the necessary alteration in the angle, the same pipe has been used in both cases.

As was the case with the tests on thin-plate nozzles, it was found expedient to block up the opening of the nozzle furthest away from the plate in the tester, and

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* Presented at a meeting of the Institution of Mechanical Engineers on Friday, May 16, 1924. The tables accompanying the report are not reproduced. The Steam Nozzles Research Committee is composed as follows:—Captain H. Riall Sankey, C.B., C.B.E., R.E., ret. Past-President, Chairman; K. Baumann; Professor H. L. Callendar, LL.D., F.R.S.; John P. Chittenden; William Dundas; Sir James B. Henderson, D.Sc. (Resigned Nov. 1923); H. M. Martin; Professor A. L. Mellanby, D.Sc.; S. L. Pearce, C.B.E.; I. V. Robinson; Frederick Samuelson; Professor G. Gerald Stoney, D.Sc., F.R.S., reporter.

† See ENGINEERING, vol. cxv, pages 356, 377 and 501.

‡ See ENGINEERING, vol. cxv, pages 380 and 501.

* In Fig. 8, First Report, the dimension given for the pitch should read—"about 1¾-in." instead of "about 1⅛-in."

to carry out the tests with three nozzles functioning. To obtain the highest velocities two nozzles only were used, but in every set of tests yet made the "overlap" between two and three nozzles falls within the accuracy of the curve. The results of some 36 tests on this nozzle with three openings are given in Table VII * of the report, shown plotted in curve 7, Fig. 3. As before, the points marked "2" represent two nozzles functioning, and the points marked "C" are check points taken on different days.

After some supplementary tests, which will be described later, the parallel portion of the throat was reduced to $\frac{1}{4}$ in., giving a 1 to 1 ratio. The results are shown in Table VIII and in curve 8, Fig. 3. In this table will be found the results of a few tests taken with a distance of 4 in. from the centre of the jet to the impulse plate, instead of the standard distance of $2\frac{1}{2}$ in. These results are marked with a small figure 4 on the curve, and it will be noted that, as far as they go, they fall within the band of accuracy of the standard tests. Many more observations would be required, however, before anything definite in this respect can be stated, as the differences are very small.

It was thought advisable to investigate the effect of an intermediate throat length between 1 to 1 and no parallel portion at all, so that tests taken with $\frac{1}{2}$ to 1 throat are recorded in Table IX and shown in curve 9, Fig. 3. The experiments were not carried over to the lower velocities, as no perceptible difference could be detected within the range actually covered.

Table X and curve 10, Fig. 3, give the results of tests of this nozzle with no parallel portion in the throat. The curve follows in general the same shape as the other three curves, but the same degree of accuracy could not be obtained, as is shown by a wider divergence of test points at similar velocities. Too much stress should, possibly, not be laid on this point except that it tends to confirm the experience of the similar nozzle with thin partition plates, namely, that an impulse nozzle with no parallel tail portion is not quite so stable as one in which a certain amount of guidance is provided.

On curve 8 are also shown the results of two tests at about 470 ft. per second, which are lower than the two tests at 650 ft. per second. To a certain extent this peculiarity, which is new, repeats itself on the 0/1 throat of curve 10, and it is, perhaps, unfortunate that curve 9 was not completed in order to supply further evidence on this point. It is hardly possible to do more at present than to note that after all due precautions had been taken and after the test results had been subjected to very careful scrutiny these points emerged as having been obtained. One result of the curves shown in Fig. 3 is to demonstrate that in a 20-deg. nozzle with thick partition plates and with considerable other disturbing influences at work the effect of length of throat is negligible between ratios of 3 to 1 and 0 to 1.

Impulse Nozzles, 20 deg. Nominal Angle, Thick Partition Plates with Chamfered Exit.—A series of supplementary tests on the same nozzle-box were carried out concurrently with the tests just recorded. The object of these tests, which were first suggested by Mr. F. Samuelson, was to detect the effect, if any, of chamfering the exit edge of the forward plate of each nozzle, and so to diminish the "flapping" effect of the flat surface, which in the case of $\frac{3}{16}$-in. plates, with a nominal angle of 20 deg., amounted to about $\frac{3}{16}$-in. between each nozzle. The details of the three chamfers which were tested may be seen in Fig. 4. After the tests of the 3/1 throat nozzles (Table VII) had been completed, a 6-in. radius chamfer was worked by hand to template across the forward exit edge of the three plates, and the results of the tests are given in Table XI and shown plotted in Curve 11, Fig. 5. The length of this chamfer prevented tests on a 2/1 parallel throat being made, but after the final tests of Fig. 3 were completed, the nozzle was again radius chamfered. The test results for this 0/1 throat radius chamfer are shown in Table XII and the curve is marked 12 in Fig. 5.

A further series (Table XIII and Curve 13, Fig. 5) was taken to determine whether any difference could be detected between a carefully radiused chamfer and a flat chamfer (see Fig. 4). The difference appears to be either negligible or, if anything, in favour of the flat chamfer. Fig. 6 shows a photograph of this nozzle. The chamfer reduced the flat portion from $\frac{3}{16}$-in. to $\frac{1}{16}$-in. The back nozzle was blocked up.

Fig. 7 shows the mean average curves computed, respectively, from the four curves of Fig. 3 (non-chamfered) and the three curves of Fig. 5 (chamfered). To these has been added, for comparison, the mean average curve of the thin plate nozzle from Fig. 4 of the Second Report. The figure shows very clearly the detrimental effect of flat surfaces in the exit plane of the nozzles, and the improvements which may be anticipated by suitable chamfering.

The Efflux Angles of the Steam.—The 20 deg. nominal angle impulse nozzle-box, with thick partition-plates, formed one of the series which was tested for efflux angle of the steam and analysed in the Second Report (pages 329 *et seq.*). It was there pointed out how serious the effect of flat surfaces in the exit plane of the nozzle appeared to be, in that the mean angle of efflux of the steam jet at a distance of $2\frac{1}{2}$ in. away from the centre of the nozzle was only about 14 deg. for a 3 to 1 throat ratio where the mean geometrical angle was 19° 10′. The nozzle box was set at this angle of 14 deg. in the tester for all the tests recorded in Tables VII to XIII (*see* Fig. 2). As a check that the jet impact was practically normal throughout the range of these tests, it was found that the cage lever was in all cases perfectly free, so free, in fact, that in spite of its large mass it tended to oscillate of itself. After the nozzle had been chamfered the angle of the forward surface of the partition plate was considerably affected. The final 20 deg. nominal thick plate nozzles, 0/1 throat, with flat chamfer, had the following geometrical angles of exit at the forward ends of the partition plates: 11° 55′, 12° 6′, and 12° 42′, or a mean value of 12° 14′.

All the efflux angle tests of the First and Second Reports were taken by a photographic method which, though enabling the angle to be read to $\frac{1}{4}$ deg., were very laborious and practically absorbed the whole time of one research assistant. Further experimenting by direct comparison with this photographic method has now shown that an accuracy of $\frac{1}{4}$ deg. may be obtained by an optical method which is as follows: An adjustable stand with motions in two directions at right angles to one another carried a graduated scale of angles and was placed about 3 ft. away on one side of the nozzle-box. A telescope with cross wires was mounted at the same distance on the other side and the two were aligned to give rectilinear projection from the scale to the telescope across the wire carrying

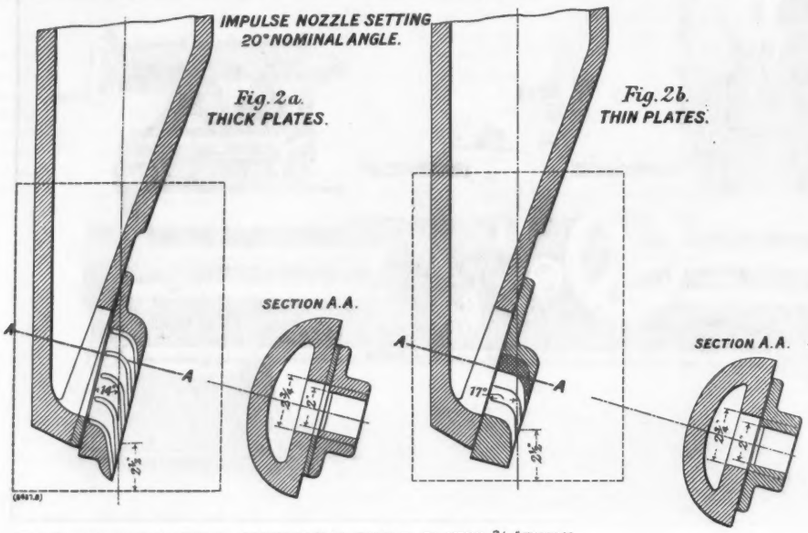


Fig. 3. IMPULSE NOZZLE. 20° NOMINAL ANGLE. PLATES 3/16" THICK.

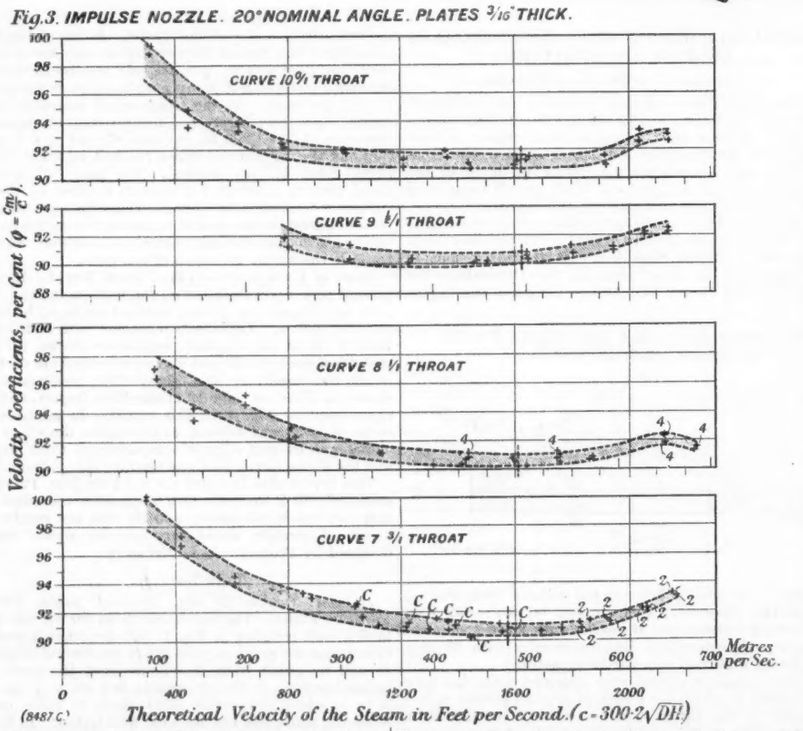
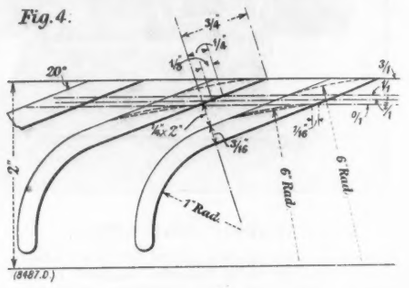


Fig. 4.



* Owing to pressure on our space, it is not possible to reproduce Tables VII to XVI of the Report.—ED. E.

the pointer in the jet. An improved pointer was devised which was similar to the shaped vane of Fig. 6, page 331 of the Second Report, except that the end was pointed and the last ¼ in. was twisted at right angles to present a tapering flat surface to the eye. This indicator gave little vibration and showed no tendency to travel along the steel wire, but unless it was made of spring steel, softened in order to shape it and afterwards re-tempered, it could not withstand the breaking force of the jet at high pressures. By this method the angles of efflux close up to the face of the centre of the flat chamfered nozzle were found to have the values which are appended.

Pressure ratio	0·90	0·75	0·60	0·50
Angle (to nearest ½ deg.)	10½ deg.	11 deg.	11½ deg.	12 deg.

A curve plotted from these figures is shown in the middle section of Fig. 8, which is a reproduction, with additions, of Fig. 7 (page 332), Second Report. It so happened that the mean geometrical angle of this nozzle, namely, 12° 14′, practically coincided with the angle 12° 11′ of the 12 deg. nominal thin plate nozzle with a 3/1 throat. If the curve just plotted is transferred, as shown, to the left-hand section of Fig. 8, it will be found to be of similar shape to this 12 deg. nominal thin plate nozzle, but about 1 deg. nearer to the mean geometrical angle at the pressure ratio of 0·90.

By analogy with Fig. 9 (page 335, Second Report) the angle of efflux of the chamfered nozzles 2½ in. away would amount to 1 deg. less than the above figures, or about 10½ deg. against the 14 deg. of the setting. But a difference of 3½ deg. at a distance of 2½ in. is only an offset of $\frac{5}{32}$ in. and, as has been seen, this had no binding effect on the spindle of the cage. The secant of 3½ deg. is 1·002, so that even if the whole of the jet were stream-line and offset as above, instead of spreading out conically as it really does, the effect on the reaction would be within the degree of accuracy desired (1 in 500).

It may be noted that a similar check was taken on the efflux angles of the 20 deg. nominal thin plate nozzles recorded in Fig. 1 of the Second Report (page 318)

Fig. 5. IMPULSE NOZZLE. 20° NOMINAL ANGLE. PLATES 3/16 THICK WITH CHAMFERED EXIT.

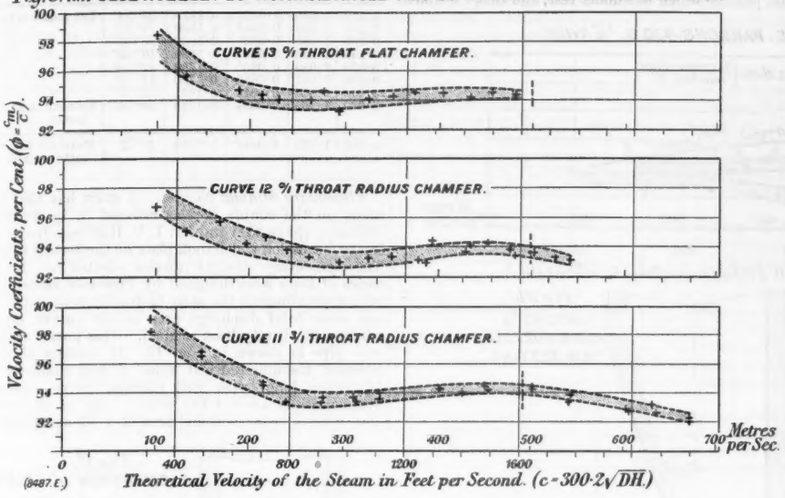

CURVE 13 0/1 THROAT FLAT CHAMFER.
CURVE 12 0/1 THROAT RADIUS CHAMFER.
CURVE 11 3/1 THROAT RADIUS CHAMFER.
Velocity Coefficients, per Cent. ($\phi = \frac{v_m}{c}$).
100
98
96
94
92
100 200 300 400 500 600 700 Metres per Sec.
0 400 800 1200 1600
(8487.E.)
Theoretical Velocity of the Steam in Feet per Second. ($c = 300{\cdot}2\sqrt{DH}$.)

Fig. 7. IMPULSE NOZZLES. THICK PLATES, SHOWING EFFECTS OF CHAMFERING.

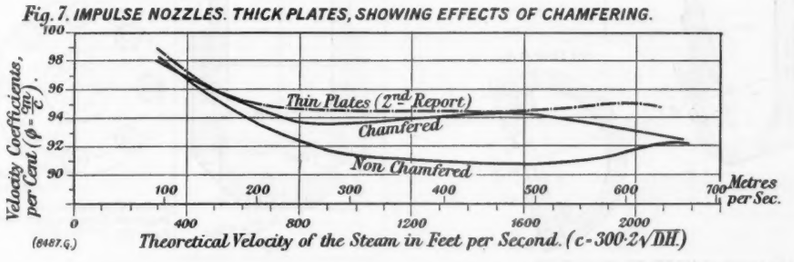
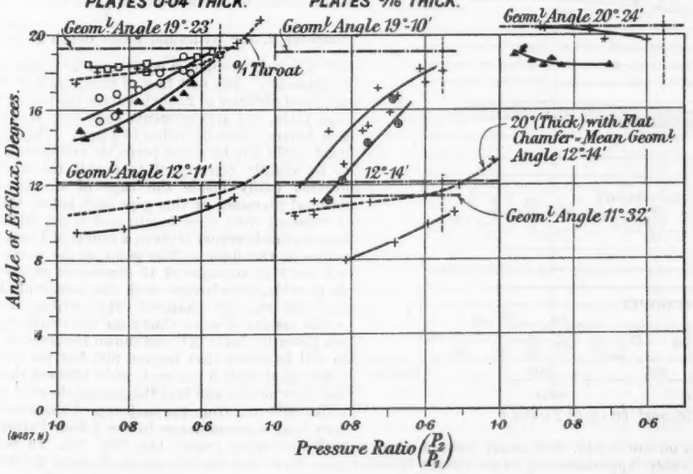


Fig. 8. *IMPULSE NOZZLE. 3/1 THROAT. PLATES 0·04″ THICK.* *IMPULSE NOZZLE. 3/1 THROAT. PLATES 3/16″ THICK.* *REACTION NOZZLE. PARSONS 480 B.*



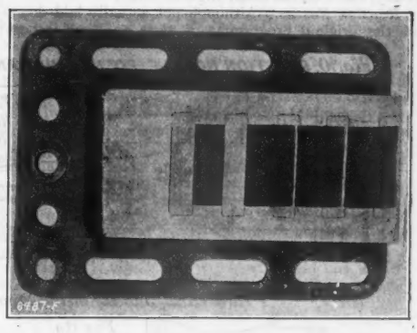
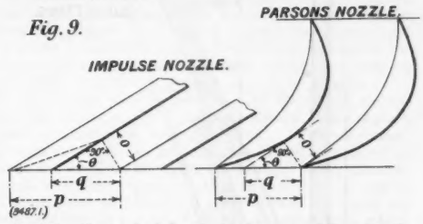


FIG. 6. 20 DEG. IMPULSE (CHAMFERED) NOZZLE.

Fig. 9.



after the throat had been cut down to 0/1, with the following result close up to the centre nozzle.

Pressure ratio ...	0·90	0·75	0·60	0·50
Angle (to nearest ½ deg.)	18 deg.	18½ deg.	18½ deg.	19½ deg.

The results of these tests have been added to the left-hand section of Fig. 8. It will be seen that this curve coincides to all intents and purposes with the curve taken close up to the 3/1 throat and shown with square spots on Fig. 8.

It will be seen that there are, in reality, two angles to be considered in the case of an impulse nozzle, which consists of cast-in parallel plates of appreciable thickness as shown in Fig. 9. There is first the angle (θ) made between the parallel plates and the plane of the diaphragm. There is secondly an angle (δ) made between the chamfered plates and the plane of the diaphragm. The first angle (θ) is the geometrical angle of the nozzle and $\sin\theta = \frac{o}{q}$. The second angle (δ) may be termed the "reference angle" of the nozzle and $\sin\delta = \frac{o}{p}$.

An application of the results of such an analysis to the nozzles already tested by the Committee is given, in round numbers, in the accompanying table.

TABLE.

—	$\frac{o}{q}$	θ Degs.	$\frac{o}{p}$	δ Degs.	Angle of Exit Degs.	Difference Degs.
20 deg. thin plate	0·34	20	0·308	18·0	17·0	−1·0
20 deg. thick plate	0·34	20	0·190	11·0	14·0	+3·0
Do. Chamfered	0·34	20	0·190	11·0	10·5	−0·5
12 deg. thin plate	0·21	12	0·178	10·3	10·5	+0·2
12 deg. thick plate	0·21	12	0·121	7·0	6·0	−1·0
1-in. Parsons ..	0·61	37	0·350	20·5	18·5	−2·0
½-in. Parsons ..	0·61	37	0·350	20·5	18·5	−2·0

The effect on the angle of the steam, of chamfering in the 20 deg. thick plate nozzles was found to be small. Chamfering has not yet been tried for the 12-deg. thick plate nozzles, but it is expected that similar results will be obtained. This table shows that the angle of exit of the steam is very nearly the reference angle δ, and not the geometrical angle θ, as is often assumed in design. This has an important bearing on the velocity diagram and on the ratio of nozzle-height to blade-height. If a similar analysis is applied to Parsons normal blading (Fig. 9), it will be seen that such blading approximates to an impulse nozzle with thick plates chamfered off, but with a geometrical angle θ of about 37 deg. The usual angle measured in Parsons nozzles, however, is not θ but δ.

The deductions from this work appear to be :—

1. That the angle of setting in the tester of 14 deg. for the 20 deg. nominal thick-plate nozzles was satisfactory.
2. That the angle of efflux of thick plate impulse

nozzles whether chamfered or not is approximately the "reference" angle whose sine is $\frac{o}{p}$ and not the geometrical angle whose sine is $\frac{o}{q}$.

3. The length of throat (with thin plates) has little, if any, effect on the mean angle of efflux.

Reaction Nozzles.—Although not actually laid down in the original programme of tests on First Report (page 18), the Committee considered it advisable to obtain some tests on smaller reaction nozzles than the 1-in. 480 B Parsons blading of the Second Report (page 326). For this purpose the nozzle-box shown in Fig. 2 (page 327, Second Report) was adapted to hold ten ⅜-in. 430 B Parsons blading and was reset, with additional wedges and packing pieces, on to the original pipe as used for the larger Parsons nozzles.

The results of 38 tests taken with this arrangement are shown in Fig. 10 on the curve marked 14*a*. It will be noted that considerable instability was found, particularly at lower velocities, and that the curve in general is very low in efficiency and different in shape from any previously obtained. Some ten tests were taken with ten nozzles functioning and are shown by a curve drawn through Δ-shaped points. The remaining twenty-eight tests, marked by small circles, were taken with eight nozzles open, after a lip inside the nozzle pipe had been removed in order to give smoother entry. It was not realised how bad the collection of wedges and packings had become until this nozzle and its pipe were set out on paper. The result may be seen in Fig. 11*a*. It then became apparent that the nozzle passage was only a small portion of the steam passage which was under test, and that the above tests, shown on curve 14*a*, were really tests of nozzles with a bad entry, approximating to an oblique funnel. The alterations which were made between the ten-nozzle and the eight-nozzle tests are shown in Fig. 11*a* by dotted cross-hatched lines.

A completely new pipe and nozzle-box were made as shown in Fig. 11*b*, and satisfactory tests were obtained as given in Table XIV and shown plotted in Fig. 10, as curve 14. The dimensions of this nozzle are as given in the table in the next column.

The 1-in. Parsons nozzles curve from page 330 of the Second Report has been added in a chain dotted line. It will be seen that the true ⅜-in. nozzles curve is a replica of the 1-in. curve though with a lower efficiency. The individual test points also lie closer to the mean curve than is the case with the "old setting," pointing to greater stability. Such an entry in the case of impulse nozzles would probably have a similar effect.

Fig. 10. REACTION NOZZLE. 20° NOMINAL ANGLE. PARSONS 430 B. ⅜" WIDE.

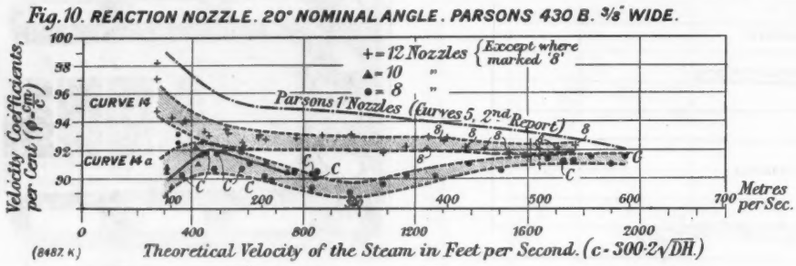

+ = 12 Nozzles {Except where marked '8'
▲ = 10 "
● = 8 "
Parsons 1" Nozzles (Curves 5, 2nd Report)
CURVE 14
CURVE 14a
Velocity Coefficients, per Cent (ρ = m/c)
Metres per Sec.
(8487.K)
Theoretical Velocity of the Steam in Feet per Second. (c = 300·2√DH.)

Fig. 11a. PARSONS ⅜" 430 B NOZZLES "OLD SETTING."

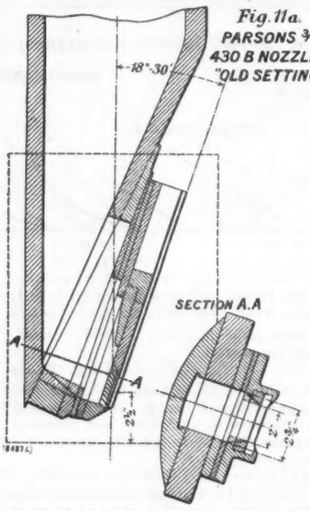


Fig. 11b. PARSONS ⅜" 430 B NOZZLES. "NEW SETTING."

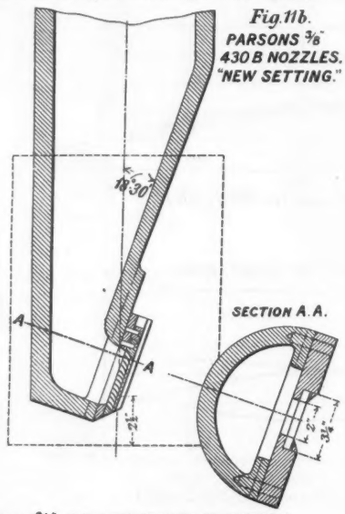
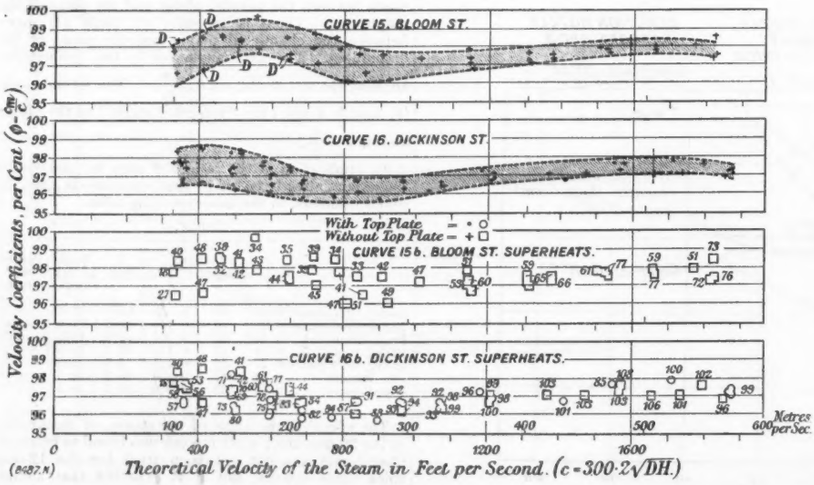


Fig. 13. STRAIGHT ELEMENTARY NOZZLES. ½" DIA. 1¾" LONG, 7 NOZZLES IN ACTION.

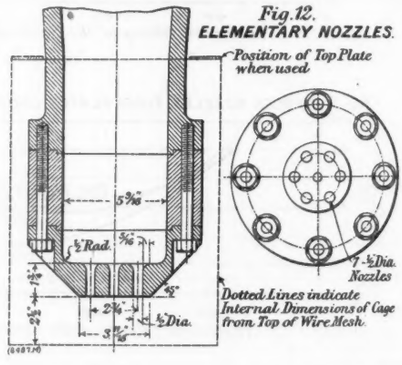

CURVE 15. BLOOM ST.
CURVE 16. DICKINSON ST.
With Top Plate = • ○
Without Top Plate = + □
CURVE 15b. BLOOM ST. SUPERHEATS.
CURVE 16b. DICKINSON ST. SUPERHEATS.
Velocity Coefficients, per Cent (ρ = m/c)
Metres per Sec.
(8487.N)
Theoretical Velocity of the Steam in Feet per Second. (c = 300·2√DH.)

Parsons 430 B Nominal Angle 20 deg.

Pitch p (ins.)	Nozzle height h (ins.)	Throat opening (at exit) o (ins.)	Throat area (at exit) a (sq. in.)	Geom. angle. $\sin^{-1}\frac{o}{p}$	Remarks.
0·250	1·958	0·0878	0·1719	20° 34′	Top nozzle in tester.
0·260	1·959	0·0868	0·1700	19° 30′	
0·260	1·955	0·0926	0·1820	20° 52′	
0·255	1·948	0·0862	0·1680	19° 45′	
0·250	1·953	0·0850	0·1660	19° 53′	
0·280	1·941	0·0886	0·1720	18° 27′	
0·240	1·948	0·0940	0·1831	23° 3′	
0·250	1·955	0·0884	0·1728	20° 43′	Bottom nozzle in tester.
0·255	1·953	0·0887	1·3858	20° 21′	Mean (or total) for eight nozzles.

Elementary Straight Nozzles.—A start has also been made on the simple nozzles referred to by Professor Mellanby (page 351) and Mr. I. V. Robinson (page 356) in the discussion which took place on the Second Report. The elementary straight nozzles selected for the first series of tests were designed by Professor Mellanby to give approximately the same hydraulic mean depth and the same total discharge area as the curved nozzles which had already been studied. This nozzle with its new pipe is shown in Fig. 12. It consists of seven circular, machine-finished holes, ⅛ inch diameter by 1¾ inches long, with well rounded entry, arranged symmetrically around the central axis of the tester. This gives a cross sectional area of 1·37 square inches as compared with the average of 1·5 square inch of the curved forms of nozzles. For a slit with opening o the hydraulic mean depth is $\frac{o}{2}$, and for a pipe with diameter d, the hydraulic mean depth is $\frac{d}{4}$; hence a slit of ¼ inch opening is equivalent to a pipe of ½ inch in diameter. The exit face of this nozzle is set at the standard distance of 2½ inches from the top mesh of the cage plate, but arrangements have been made to alter this distance from 6¼ inches to ¼ inch. The nozzle pipe itself could not be made perfectly cylindrical, but had to be slightly convergent to enable the whole to be lowered easily inside the cage of the tester. The internal diameter of this pipe just before the nozzles is constant over some length and is 5/16 inches. The bottom inside corner is given a radius of ⅛ inch to avoid eddies in the steam. The point of the nozzle itself is cut away at an angle of 45 degrees to prevent, as far as possible, interference with the escape of the steam into the exhaust chamber after striking the plate.

Fig. 12. ELEMENTARY NOZZLES.



The results of some thirty-six tests with this nozzle are given in Table XV and shown in curves 15, Fig. 13. It will be noted that beyond 800 feet per second this nozzle is at least 5 per cent. more efficient than any of the other nozzles and that the general shape of the curve, whilst differing from the majority of the other nozzles, does bear a resemblance to the ⅜-inch Parsons nozzle with bad entry (curve 14*a*, Fig. 10). In both these cases there is a distinct rise in efficiency between about 900 feet per second and the critical velocity of about 1,600 feet per second, which is more pronounced than in most of the other nozzles tested up to the present. There is also an indication of the "turning over" of the curves at very low velocities, which was predicted by Mr. H. M. Martin in the discussion on the Second Report (page 351).

The tests of which the results are shown in this curve were carried out during the summer of 1923 when the steam supply was obtained from the Bloom Street Station. This arrangement necessitated carrying the steam main across a bridge over a canal with the result that the degree of superheat obtainable was not

so great as during the winter months. It so happened that at the time when the steam supply was changed over from the Bloom Street Station to the Dickinson Street Station the Committee decided to investigate the effect of putting a top plate on the cage. It had been pointed out that the original impulse-reaction cage experiments at Rugby involved a cage of a slightly different form from the one which was being used in the tester, the main difference being that whereas at Rugby there was a plate at the top as well as at the bottom, in the main tester there was also a space between the top of the cage and the nozzle pipe. The difference can be seen by reference to Figs. 2 and 4 in the First Report. An aluminium plate $\frac{1}{16}$-inch thick in two halves was clipped to the top of the cage (*see* Fig. 12). The annular gap between this plate and the nozzle pipe, which had been trued up on a lathe, was not more than $\frac{1}{10}$-inch.

The results of the tests carried out with this arrangement are shown in Table XVI and are indicated by black dots in curve 16, Fig. 13. A series of intermediate tests were also carried out without the plate, and the results of these are shown in Table XVI*a* being marked on curve 16 by small crosses. In all, the plate was put on and removed three times, and there seems to be little doubt that its effect is negligible as far as comparison has been made.

It should be mentioned that previous to the plate tests a search tube had been run into the top of the cage which in every case showed that there was either no flow of steam at the top, or a slight difference in pressure which was sometimes negative and sometimes positive. The maximum difference either way amounted to 0·1 inch of water. Moreover, very careful search tube measurements were carried out in three different parts of the tester and no difference greater than 0·1 inch of water could be detected in any of them, even with the largest pressure drops.

It will be noted that the last tests carried out at Dickinson Street, with the higher superheat, gave a distinctly different curve from that derived from the first tests on the elementary nozzle. The curve is transposed to the left and indicates slightly less efficiency. This can be seen in Fig. 14 which shows the two mean curves superimposed. The reason for this appears to be the increased degree of superheat obtainable at Dickinson Street and the comparison can be readily seen from a study of curves 15*b* and 16*b* in Fig. 13 which are replicas of the two upper curves, but which show by figures the degree of initial superheat for each corresponding test. The various superheats in degrees C. with a margin of ± 10 deg. for the two curves are as follows :—

——	Low Velocities.	Medium Velocities.	High Velocities.
Bloom Street.. ..	30°	40°	60°
Dickinson Street ..	70°	85°	95°

[The degree of superheat is not under the control of the experimenters.]

It should be noted that where low superheats of the order of 40 degrees are obtained at the low velocities in Dickinson Street the curve agrees with that obtained from experiments carried out at Bloom Street. This agreement is indicated by the points marked D in curve 15, which are taken from curve 16.

Calibrations.—The calibrations mentioned in the Second Report have all been repeated, particular care having been given to the measuring instruments. A further calibration has also been made on the leverage factor of $\frac{14 \cdot 95}{15 \cdot 50}$ which is used in obtaining the value of the impulse of the jet (F), and which was determined from measurements of the two arms of the lever. A check calibration was made by placing known weights upon the impact plate inside the tester, the lever being brought back to its equilibrium position whilst the sleeve was kept revolving and well lubricated. The following Table shows the result of this calibration.

Known Weight on Impulse Plate.	Balancing Weight in Scale Pan.	Zero Reading. Weight to balance unloaded Plate and Lever.	Calculated load on Plate with Leverage Factor $\frac{14 \cdot 95}{15 \cdot 50}$ taken as ——.
Lb.	Lb.	Lb.	Lb.
4	5·98	1·83	4·003
7	9·09	1·83	7·003
14	16·35	1·83	14·01
20	22·58	1·83	20·02
30	32·95	1·83	30·02
40	43·28	1·83	39·98

From the foregoing it can be seen that in no case within the whole range from 4 lb. to 40 lb. on the plate, is the error in measurement of this load greater than 0·1 per cent.

Conclusions.—The present Report covers work of a similar nature to that which is contained in the First and Second Reports of the committee. The main conclusions may be summarised as follows :—

1. The general shape of the curves obtained for the velocity coefficients of steam nozzles is corroborated and in one or two cases the curve has been carried sufficiently far into the low velocity region to indicate that it "turns over," as predicted by Mr. Martin.

2. The effect of chamfering thick plates of convergent impulse nozzles is clearly shown by the work in this report. It would appear that a thick plate nozzle with a chamfered exit can be made as efficient, over a considerable working range, as a nozzle with very thin plates.

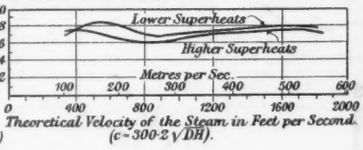
3. A straight elementary nozzle is in general 5 per cent. more efficient than the practical types of nozzles which have been tested. The general shape of the curve, however, is very similar. A review of both Second and Third Reports goes to show that the condition of entry or of exit is important. The steam should approach the nozzle as smoothly and as slowly as possible and no flat surfaces should be left on the exit side of any nozzle.

4. The effect of superheat, as shown in the case of the straight elementary nozzles with their higher efficiency, appears to lower the absolute efficiency of the nozzle and at the same time to move the curve bodily to the left. In this connection it should be noted that : (*a*) a single set of nozzles only is being tested here and not a series of stages ; (*b*) the comparison is between one degree of superheat and another, that is to say, the steam is completely superheated from entry to exit conditions, but in one case the average temperature is some 40 deg. C. higher.

5. It is necessary to add the following information to the curves so far obtained, in view of conclusion No. 4 :

All the curves in the second report were deduced from tests on steam from the Bloom Street Station

Fig. 14. STRAIGHT ELEMENTARY NOZZLES SHOWING EFFECTS OF SUPERHEAT.



(which gave, in general, lower superheats), with the exception of the 3/1 throat impulse (curve 1, Fig. 1, Second Report, page 319), and the first Parsons nozzles setting (curve 5*a*, Fig. 3, Second Report, page 327). The superheat effect may therefore have contributed to the fact that these two curves gave lower velocity coefficients than the remainder of the tests, in addition to the reasons suggested, namely, length of throat in the case of the impulse nozzle and poor conditions of entry and exit in the Parsons nozzle.

All the curves in this Report, on the other hand, were tested on steam from the Dickinson Street Station (which gave, generally, higher initial superheats), with the exception of straight elementary nozzles (curve 16, Fig. 13) already referred to, and the Parsons $\frac{3}{8}$-in. nozzles of curve 14, Fig. 10.

Although the two Parsons nozzles were tested at Bloom-street Station, a comparison of the initial superheats attained will show a mean increase of about 30 deg. for the $\frac{3}{8}$-in. nozzle. It is therefore possible that the curve for this nozzle should be lifted $\frac{1}{2}$ per cent. at low velocities to $\frac{1}{4}$ per cent. at high velocities for direct comparison with the 1-in. nozzle of the Second Report. The velocity coefficients of the thick plate impulse nozzles, with and without chamfer, may perhaps be raised from $\frac{1}{4}$ per cent. to 1 per cent. when comparing them with the results of the thin plate impulse nozzles given in the Second Report.

The work of the committee is proceeding without interruption. The conclusions reached so far may be taken to apply to the particular nozzles already tested. These are, in brief : (*a*) Parsons standard 1-in. and $\frac{3}{8}$-in. nozzles ; (*b*) impulse convergent 20 deg. nozzles, with very thin partition plate (0·04 in.) ; (*c*) impulse convergent nozzles with very thick partition plate ($\frac{3}{16}$-in.), with and without chamfer at the exit edge ; (*d*) straight elementary nozzles, $\frac{1}{2}$ in. diameter. In all tests the distance between the exit face of the nozzle and the top mesh of the cage plate was $2\frac{1}{2}$ in.

The Committee have again to acknowledge their great indebtedness to the British Electrical and Allied Industries Research Association for their contributions towards the cost of the research, and would also like to place on record their satisfaction with the work done by the following research assistants : Messrs. J. E. Shakeshaft, T. A. Wordsell, and F. M. Owner. They are also grateful for the inspiration and help they received from the discussions on the Second Report when this was read in London and in Manchester.

IRRIGATION PUMPING MACHINERY (GEZIRA SCHEME), SUDAN.*

By RICHARD W. ALLEN, C.B.E., Vice-President.

(*Concluded from page* 656.)

Drainage Arrangements.—A drainage-pump is installed in the engine-room for the basement, which, being some 30 ft. below flood level, requires constant pumping out. The basement of the engine-room runs the full length of each side of the building, the floor sloping in all directions to the sump. The drainage-pump can also be run, as is necessary in flood time, when the main station is not working, by means of a cross-over connection, by the 15-h.p. hot-bulb engine and dynamo in the workshop. For emergency use against the contingency of all current failing, an auxiliary hand-operated semi-rotary pump with 2-in. branches also draws from the same sump.

As a standby for make-up purposes, a small plunger pump of 2-in. bore is fitted, and of a capacity of about 2,000 gallons per hour against a maximum head of 120 ft. This pump, known as the domestic pump, in addition, serves also for the initial filling of the settling tank, and in case this tank requires cleaning out, and to avoid shutting down, it will also supply water to the steel tanks in the engine-room.

Electrical Arrangements.—Two 26 kw. dynamos, belt-driven are provided for supplying current for the electric lighting of all the buildings, roads, workshops and living quarters, for the cooling water pumps, for the alarm-gear on the warm water system, and for the fuel-oil pumps. A 15-b.h.p. hot-bulb engine and dynamo in the adjoining workshop supplies current for police lights in the main station, which can thus be lit before any of the engines have to be started.

Air-Supply and Ventilation.—An important matter is that of the supply of fresh air for the Diesel engines and ventilation of the engine room. The severe sand-storms to which the building is liable make it essential that it should be air-tight, no openings being allowed, while even the ridges in the roof have to be sealed. The method of vetilation adopted was to install on the east side of the building, the direction from which sand storms are least likely to blow, two air-filters, running from each of which are 25-in. diameter pipes leading to two fans, belt-driven from shafting in the engine-room. The fans discharge in a direction parallel with the length of the buildings, thus ensuring the best circulation. The Diesel engines draw their air from the engine-room. This arrangement maintains a very satisfactory temperature even under the hottest sun conditions.

Suction-Wells and Pipes.—Each main pump has its own suction-pipe, 40 in. in diameter, constructed of steel, 184 ft. long. The suction-wells are 16½ ft. across and of a depth nearly 10 ft. below lowest water-level, with a concrete bottom and brickwork shaft and of U-shape, with a grid on the open side. They were built some 40 ft. from the river at lowest Nile, and the suction-pipes having been put in, the river was dammed off and channels cut in its bed to allow water to enter the wells after which the dam was removed. To enable the 40-in. suction pipes, which were made of $\frac{3}{8}$-in. steel plate to carry the weight of nearly 40 ft. of earth, they were specially strengthened by angle-iron rings, and were built on concrete piers, spaced 6 ft. apart, and carried down to a good subsoil.

Provision had to be made on these pipes for expansion and contraction, which was particularly pronounced while the trench was being kept open to allow tests to be made. This was provided for by fixing the pump end by bricking and grouting into the wall, the other end being free, while the bend in the suction well was supported on rolled steel joists, but not bolted, thus allowing for the necessary movement. In order to permit the fitting of the suction-pipes to go forward without waiting for the pumps, and at the same time to avoid the use of a template pipe, the method adopted for coupling the pipes to the pumps was by means of expansion pipes. This will enable the pumps, if necessary, to be readily dismantled.

Discharge Pipes.—On the other side of the building, since the whole of the distance of the 40-in. discharge pipes to their junction with the rising main was in "cotton soil," which on becoming wet has been known to cause the collapse of plant and machinery built upon it, special precautions had to be taken to ensure a good foundation, and the piers supporting these pipes were therefore taken to the same depth as for the main building. The pipes are of steel, $\frac{3}{8}$ in. thick and 115 ft. long. A problem here encountered was to connect the three 40-in. discharge pipes, which were converging and rising at an angle of approximately 4 deg., to the three-way piece which united them with the 72-in. rising main. Here the pipes were securely fixed at one end to the wall of the building and expansion-pipes were fitted, the supporting piers being so

* Paper read before the Institution of Mechanical Engineers on Friday, May 9, 1924. Abridged.

constructed as to allow of free movement. To ensure that these pipes came into line, the flanges of the 40-in. bend above the butterfly-valve over the pump were left loose, and, after being set at the correct angle, were drilled and riveted on site, a closing length being left on each section and cut to suit.

Rising Main (Figs. 7, 8 and 9).—The rising main is about 2,130 ft. long and connects to the delivery or feeder canal. The pipes for this main were 10 ft. long and $\frac{5}{16}$ in. plate, each ring, in order to decrease the cost of transport, being in three sections, which were riveted and caulked together on site so as to be perfectly watertight, this being necessary to avoid leakage, with its attendant consequences to the foundations. All riveting and caulking was done by native labour, and very complete tests were made to get the pipe quite tight, finally with entirely satisfactory results, when the trench was filled in. The rising main was fitted with a 24-in. vent-pipe to a height of 30 ft. above the three-way piece.

A trench was dug 10 ft. deep at first, and gradually rising for the concrete piers, which were spaced 10 ft. apart and were 6 ft. 6 in. wide, 3 ft. 7 in. thick, and shaped to suit the radius of the pipe, these precautions being necessary by reason of the great weight of the pipe when filled with water. This main was securely anchored at each end and twice intermediately, dividing it into three sections, each having an expansion joint in conjunction with an anchorage. It is of interest to note that a difference of 3 in. was frequently observed in these expansion joints. The piers for the anchorages were half as wide again and twice as thick as the others.

TABLE I.—DIESEL ENGINE TEST SHEET: SHOP TRIALS.
Wad-el-Nau Pumping Station.

—	No. 1 Engine.		No. 2 Engine.				No. 3 Engine—4 Cyl.			Remarks.
Date	22/9/22.		19/10/22.		20/10/22.		20/11/22.			
Proportion at full load ..	Full	10% overload	¼	½	Full	10% overload	½	Full	10% overload	
Average mean pressure (indicated kg./cm.²)	7·25	7·91	4·03	5·51	6·98	7·42	5·42	7·02	7·39	
R.P.M.	150	150	150	151	151	151	149	150	147	
I.H.P.	1,280	1,395	710	980	1,240	1,320	950	1,240	1,280	Figures given are average values taken over considerable periods.
B.H.P.	945	1,035	472	710	956	1,040	702	960	1,010	
Mechanical efficiency per cent.	73·8	74·2	66·6	72·5	77·1	78·6	74	77·2	79	
Fuel Oil Consumption.										
Grams per i.h.p. per hr. ..	141	142	145	145	146	147	148	150	148	
Lb. „ „ „ ..	0·311	0·313	0·320	0·320	0·322	0·324	0·326	0·331	0·326	
Grams per b.h.p. per hr.	191	192	218	201	188	187	200	194	187	
Lb. „ „ „ ..	0·421	0·424	0·480	0·443	0·414	0·412	0·441	0·428	0·412	

Fig. 7. 72 INCH RISING MAIN.

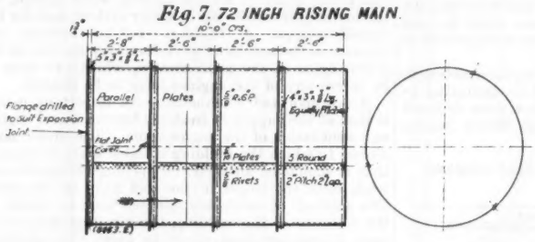
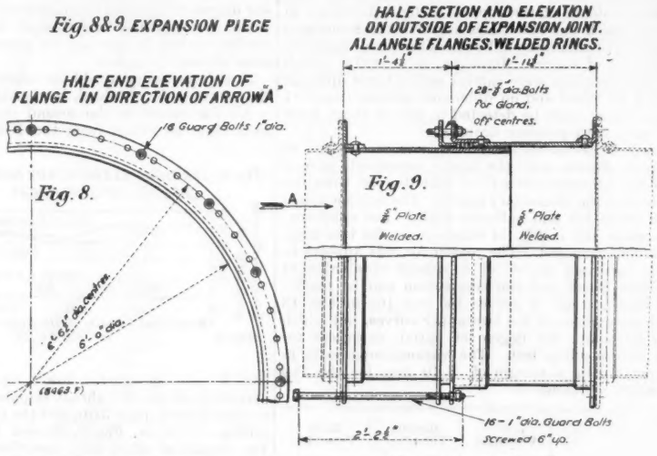


Fig. 8&9. EXPANSION PIECE


HALF END ELEVATION OF FLANGE IN DIRECTION OF ARROW A
16 Guard Bolts 1" dia.
Fig. 8.
HALF SECTION AND ELEVATION ON OUTSIDE OF EXPANSION JOINT. ALL ANGLE FLANGES. WELDED RINGS.
28-⅞" dia. Bolts For Gland. off centres.
Fig. 9.
⅝" Plate Welded.
16-1" dia. Guard Bolts Screwed 6" up.

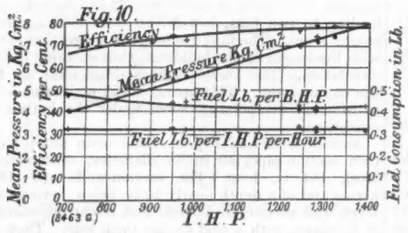


FIG. 10. SHOP TRIALS.

Four-Cylinder Diesel Engine. 630-mm. Bore. 850-mm. Stroke. 150 r.p.m.

Oil Fuel Supply and Storage Tanks.—Fuel-oil was brought to Wad-el-Nau by the Sudan Government Railway oil service cars from Port Sudan *via* Atbara and Khartoum. The fuel cars were drawn up on the railway siding alongside the storage tanks, and the electric fuel pumps delivered the oil into the storage tanks. Two fuel storage-tanks were provided, each of a capacity of 300 tons, dispatched in plates for erection on site. Each tank is fitted with inside and outside ladders, and man-holes.

The tanks were built in three tiers, the two bottom tiers being made of ¼-in. plate and the top tier of $\frac{5}{16}$-in. plate. Each tier consists of eight rounds with 2-in. laps; ⅝-in. rivets were employed 1⅞-in. pitch. The total height of each tank is 16 ft. 3 in. and the diameter 32 ft.

Delivery of Machinery to Site.—The whole of the machinery was shipped to Port Sudan and conveyed by special trains on arrival of each ship-load from Port Sudan to Wad-el-Nau *via* Atbara and Khartoum, a distance of over 700 miles and across two deserts. The Sudan Government Railway officials deserve the highest praise for their excellent organization. In view of the complicated nature and weight of the machinery, it was delivered in a most expeditious manner and no part was damaged in transit.

Railway Accommodation.—To deal with about 1,000 tons of machinery delivered in the wilds, some preparation is required, and for this purpose a special single-track railway, 6 miles long, had to be constructed from the Sudan Government Railway at Wad-el-Nau railway station to the pumping station, from sidings at which the machinery was unloaded by means of a 10-ton steam crane. The railway siding being 10 ft. higher than the entrance to the pumping station, a slipway was constructed between the two, down which all the plant was lowered on rollers to the entrance. Here it was handled by two 15-ton travelling cranes, and lowered an additional 26 ft. on to the floor of the pumping station.

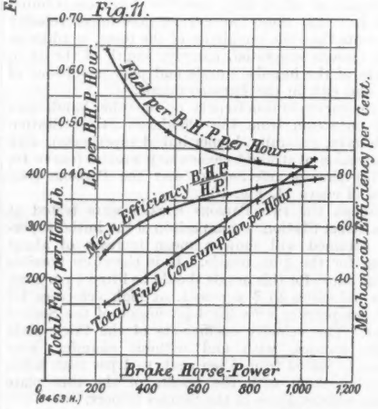


Fig. 11.
Fuel per B.H.P. per Hour
Lb. per B.H.P. Hour
Mech. Efficiency B.H.P. / I.H.P.
Total Fuel Consumption per Hour
Total Fuel per Hour Lb.
Mechanical Efficiency per Cent.
Brake Horse-Power

FIG. 11. CONSUMPTION AND EFFICIENCY CURVES.

Four-Cylinder Diesel Engine. 630-mm. Bore. 850-mm. Stroke. 150 r.p.m. Anglo-Persian Fuel Oil. Specific Gravity 0·89 at 60 deg. F. Heating Value (Average Sample) B.Th.U., 17,608 net, 18,875 gross.

Labour Employed on Erection.—For the excavation of the site preparatory to erection some hundreds of Egyptians from Assuan, who had had previous experience in this class of work, were employed, and when this was completed, they were superseded by local Sudanese and West Africans, many of whom were pilgrims, working their way either to or from Mecca. A small number of women were also employed on carrying water, bricks, &c. The machinery was finally erected by about two hundred natives, with a few Greeks and Italians.

TABLE II.—*Tests on Site.*
Wad-el-Nau Pumping Station.

—	No. 1 Engine.	No. 2 Engine.	No. 3 Engine.	—
Date	22/5/23.	23/5/23.	23/5/23.	—
Average mean pressure	6·14	6·55	6·20	NOTE.—The fuel consumptions are calculated from readings of the fuel service tanks and cannot be regarded as strictly accurate.
R.P.M.	140	140	140	
I.H.P.	1,015	1,080	1,025	
Fuel Consumption.				
Grams per i.h.p. p.h.	144	146	145	
Lb. „ „ „	0·317	0·321	0·320	
Temperatures.				
Atmosphere (deg. F)	97	96	95	—
Circulating water inlet (deg. F.) ..	89	87	90	—
Circulating water discharge (deg. F.)	122	116	118	—
Oil:—Before cooler (deg. F.) ..	134	128	129	—
After cooler (deg. F.) ..	109	108	111	

Some of the best of the Sudanese workmen had received their training in craftmanship at the Gordon College, Khartoum; others at the Government Railway workshops at Atbara. These included fitters, blacksmiths, riveters, bricklayers, and carpenters, all of whom, under the supervision of British engineers, did good work, thus affording an excellent testimonial to the training given at the College and the Railway workshops.

Trials of Machinery.—Both of the main engines and all the auxiliary machines were subjected to exhaustive trials before shipment, the results obtained from these

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

FIG. 1. MOTOR-CYCLE FIRE ENGINE; THE DARLASTON GALVANISED HOLLOW-WARE COMPANY, LIMITED.

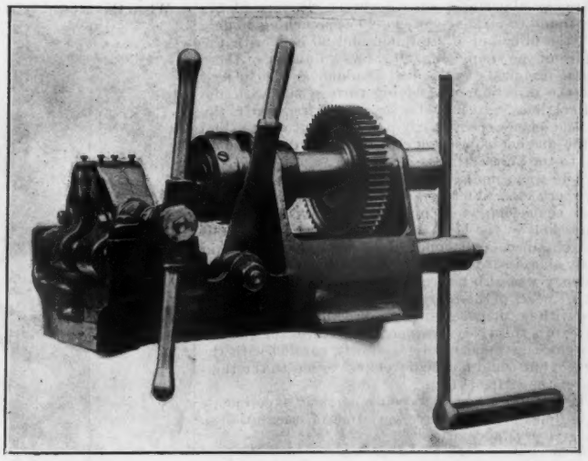


FIG. 2. BENCH SCREWING MACHINE; MESSRS. THOMAS CHATWIN, LIMITED, BIRMINGHAM.

trials proving that each of the main engines had an ample margin of power to meet all requirements under actual working conditions, where both the considerable altitude and tropical temperature affect the power developed by the engines.

During these trials the fuel consumption and the efficiency of the engines were proved to be in accordance with the requirements. The results obtained from all three engines have been tabulated and curves prepared showing the efficiencies and fuel consumptions, Tables I and II, and Figs. 10 and 11.

The final trials on site of the whole of the pumping machinery took place in the month of June, 1923, and the regular routine of pumping started in July. Owing to the very large quantity of water, it was found impracticable to measure this with any degree of accuracy. Venturi meters were not placed in the discharge-pipes, and, owing to the leakage of the banks, it was difficult to measure the water in the canal, but the engines gave the power at the correct speed. It is interesting to record that the conditions on site were as follows: the altitude was 1,300 ft. above sea-level, but barometric readings were not recorded. The air temperature during the official trials on site was 97 deg. F., and the temperature of the cooling water about 87 deg. to 90 deg. F.

EXHIBITS AT BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

IN our article last week on the British Industries Fair at Birmingham (page 644 *ante*) we noticed, among other things, a motor-cycle fire engine exhibited by the Darlaston Galvanised Hollow-ware Company, Limited, of Booth Street, Darlaston, Staffs., and a bench screwing machine by Messrs. Thomas Chatwin, Limited, of Great Tindal Street, Birmingham. We are now able to illustrate these two machines in Fig. 1 and Fig. 2 above. The fire-engine, as will be seen, consists of a standard motor-cycle constructed by Messrs. Dunford and Elliott, Limited, with a side-car attachment to carry the chemical extinguishing apparatus, ladder and hose. A fireman can also ride on the back of the side-car chassis. The main chemical extinguisher, which is mounted on trunnions so that it can be easily inverted, contains 25 gallons of liquid. In addition to this, there is a three-gallon portable extinguisher, and two other portable extinguishers of the same capacity but fitted with special "foam" liquid for smothering petrol or oil fires. A 12-ft. collapsible ladder and 25 ft. of hose also form part of the equipment. The machine is quite capable of dealing with any ordinary fire by itself, or will hold a bigger conflagration in check until regular fire-fighting machinery can be called up. Its cheapness, mobility and readiness for service should commend it to villages and isolated communities to which it will afford valuable protection.

The other article illustrated, namely, the bench screwing machine, has been put on the market to compete with the ordinary stocks and dies. It has the advantage over them that it can always be found when wanted, and even in quite unskilled hands it will enable a good thread, square with the job, to be put on any fitting or pipe within its capacity. With suitable dies it will cut either gas or Whitworth threads on material from $\frac{1}{4}$ in. to 1 in. diameter. The work is held in an open-topped self-centring vice, which will hold bends and short pieces as well as bars and pipes. The machine can be fastened to a trestle or hand-cart if the job is being done at some place where there is no bench handy, as an even less rigid fixing than is wanted for an ordinary pipe-vice is quite adequate.

CATALOGUES.

Testing Work.—Messrs. Bescroft and Partners, Limited, St. Peter's Close, Sheffield, have sent us a circular indicating the class of work they undertake in testing, chemical analysis, &c.

Lawn Mowers.—A priced list of lawn mowers made by Messrs. Ransomes, Sims and Jefferies, Limited, Ipswich, contains illustrations of machines for hand, pony, horse and motor propulsion, and ranging from 9 in. to 42 in. in width.

Roller Bearings.—A new circular of roller bearings for line shafting has been issued by Messrs. Hyatt, Limited, 56, Victoria-street, London, S.W. 1. These bearings are made in halves to enable them to be placed in position without dismantling the shaft.

Accumulators.—Messrs. Fullers United Electric Works, Limited, Chadwell Heath, Essex, have issued an excellently compiled and illustrated catalogue of stationary accumulators, containing full particulars of capacities and dimensions, together with some instructive technical notes.

Tool Handles.—Messrs. William Findlay and Sons, Newcastle-on-Tyne, have sent us a catalogue of wood handles for files, wood chisels, &c., and also of complete tools, such as bradawls, screwdrivers, chisels and gouges. Special attention has been given to the finish and metal binding of the handles.

Marine Electrical Plant.—A catalogue of electric power and light plants suitable for small pleasure or mercantile craft is to hand from the Westinghouse Electric International Company, 2, Norfolk-street, Strand, London, W.C. 2. The plants comprise a petrol engine, generator and battery.

Electrical Supplies.—Catalogues of jointing material, such as insulating tapes and compounds, and of chain-type cable hooks for supporting cables up to 4 in. diameter on walls, &c., have come to hand from Messrs. Siemens Brothers and Co., Limited, Woolwich, London, S.E. 18. Both catalogues state prices and give all the necessary technical information.

Venturi Meters.—A catalogue of Venturi meters issued by Messrs. George Kent, Limited, 199, High Holborn, London, W.C. 1, contains excellent explanatory matter of the various types of meters made and of the indicating and recording instruments and electrical attachments for use with these meters. The "Orivent" tube dealt with in the catalogue is a combination of an orifice and a Venturi tube, which is less costly in construction but involves a somewhat greater loss of head. The catalogue is fully illustrated and contains some reproductions of graphical records obtained with Venturi meters.

THE PRODUCTION OF LARGE CRYSTALS BY ANNEALING STRAINED IRON.*

By Professor C. A. EDWARDS, D.Sc., and L. B. PFEIL, B.Sc., A.R.S.M., University College, Swansea.

(*Concluded from page* 654.)

Conditions for Growing Largest Crystals.—The conditions under which the authors consider that the largest crystals of iron can be produced from the type of steel experimented upon are summarised as below: (1) A grain-size of approximately 120 grains per square millimetre is required (grain-size B). This can be obtained by decarburising at a temperature of 950 deg. C. for 48 hours, followed by slow cooling (12 hours from 950 deg. to 100 deg. C.); (2) the complete removal of carbon is necessary. This can be accomplished in the above time by passing hydrogen through the furnace at the rate of $\frac{1}{100}$-th of a cubic foot per day per square inch of $\frac{1}{8}$-in. plate surface being treated; (3) an elongation of 3·25 per cent. produced by tensile pull; (4) annealing at as high a temperature as possible without reaching Ac3 (about 880 deg. C.) for 72 hours.

It should be noted that, to reveal the coarsely crystalline structure on light etching, it would be necessary first to remove the surface layers. If this be done by careful filing, the coarsely crystalline specimen may then be heated up to 880 deg. C. without recrystallisation ocurring as a result of the surface cold-work.

Tests on Large Crystals.—A number of test-pieces were cut from strips containing large crystals, so that the parallel portion in each case was occupied by a single crystal. The total length of a test-piece was 5·5 in., the parallel portion being 2·5 in. long by 0·75 in. wide by $\frac{1}{4}$ in. thick. These were then pulled to fracture, the ultimate stress and the elongation on 2 in. being measured. Tests so far made have given values from 9 to 10 tons per square inch for the ultimate stress, and from 30 to 50 per cent. for the elongation. Photographs of two broken test-pieces are shown in Figs. 21 and 22. These figures may be compared with 19·6 tons per square inch and 53·5 per cent. elongation for the decarburised steel (of fine grain-size A), and 32·4 tons per square inch and 22·0 per cent. elongation for the original steel.

A single crystal cut from the coarsely crystalline material could be rolled out to 100 times the original length, and reduced from $\frac{1}{4}$-in. thick to $\frac{1}{1000}$-in. thick without annealing and without showing any signs of cracking at the edges. The properties in this respect were similar to those of the aluminium crystals made and tested by Carpenter and Elam.

It was found, however, that under certain circumstances these large iron crystals were exceedingly brittle. If a crystal were placed in a vice in a certain way and given a sharp hammer blow, fracture could frequently be made to take place along what appeared to be a cleavage plane. A large number of crystals were broken in this manner. Only in a few cases

* Abstract of paper read at the meeting of the Iron and Steel Institute on May 8, 1924.

was it found impossible to obtain cleavage fracture, bending taking place, such as would be expected in finely crystalline iron. In the large majority of crystals tested it was found possible to obtain fractures in two planes exactly at right angles.

A remarkably large proportion of the cleavage planes were found to make angles closely approaching 45 deg. with the direction of straining, and 90 deg. with the surface of the strip. Fig. 20 shows a number of these crystal fragments selected at random, and so placed that the direction of straining corresponds with the vertical lines. It may be seen how frequently the cleavage planes occur nearly parallel (or at right angle) to the diagonal lines, which have been drawn at 45 deg. to the vertical lines.

There was some similarity in the orientation of the large crystals. Further evidence, pointing to the same conclusion, was obtained by making Brinell impressions in the large crystals. Square impressions were obtained, a diagonal of each approximating, in nearly all cases, to the direction of straining. A marked tendency was also noticed for etching pits to develop on the surface of these large crystals square in shape, and also with a diagonal in the direction of straining. Traces of a third cleavage were observed in some cases. This cleavage appeared to be nearly parallel with the surface, but could not be developed owing to the thinness of the strips ($\frac{1}{8}$ in.).

The authors propose to continue their experiments to find out to what degree variation of orientation in the large crystals exists.

In connection with the direction of these cleavage planes, Stead's explanation of the brittleness he found in certain rolled mild steel sheet is of interest. He found that fracture occurred in brittle sheets through two planes perpendicular to one another and to the surface of the sheet, and at 45 deg. to the direction of rolling. The authors think that as a result of still more careful examination it will be possible definitely to establish that large crystals grown in strained iron approximate to one orientation. If this were found to be the case it would be very important, since it would follow that those crystals in the finely crystalline aggregate which grew were also near to one orientation. The orientation in question would appear to be one offering but little resistance to deformation by slip, since two cleavage planes would coincide with planes of maximum shear during tensile straining.

Consideration of Results.—The authors feel justified in concluding that: (*a*) the conditions have been determined under which it is possible to grow large iron crystals, and (*b*) the orientations of the large crystals appear to bear a relation to the direction of straining and to the surface of the strips.

Further, two facts have been established which the authors consider to be of fundamental importance, namely: (1) the critical strain required to produce very large crystal growth on subsequent annealing varies with the initial grain-size of the material used. This variation is in the direction of a greater strain being needed as the grain-size increases. With very large crystals sufficient strain to cause growth cannot be applied, owing to recrystallisation occurring at the crystal boundaries; (2) surface crystals of the original crystalline aggregate behave differently from interior ones, requiring a greater tensile strain before they will disappear.

The following explanation is offered to assist in accounting for and in connecting together these two facts; during the deformation of an isolated crystal there is but little change in the internal arrangement of the crystal. Some change must occur, for it has been shown that single crystal tungsten filaments harden by cold-work. A hardening was also found by the authors when large iron crystals were cold-worked. In the case of single iron crystals, however, whatever change occurs (up to 25 per cent. elongation) is removed on annealing without being accompanied by recrystallisation. Nor does recrystallisation set in if the temperature be raised to just below Ac3. In the case of a single crystal it is considered that deformation occurs by a process of slip, causing little change in the crystal lattice. If, however, two crystals in contact are deformed, interference with slip will occur, owing to the change in the direction of the slip planes in passing from one crystal to the other. Under these circumstances some other kind of movement occurs during deformation; this second kind of movement will be most intense at and near the crystal boundaries, and less so as the distance from the boundaries increases.

X-ray analysis does not indicate any difference between the lattice constants of cold-worked and of annealed metals, but shows a relation in the former between the directions of the crystallographic axes and the direction of straining. The second type of deformation (caused by interference with slip) is interpreted, therefore, as a rotation of the crystallographic axes accompanied by elastic strains (the latter not being detected by X-ray analysis). The depth to which this change penetrates from the boundaries depends upon the degree of deformation. With small crystals but little deformation will cause the depth to correspond with the radius of the crystals. The larger the crystals, the greater will be the deformation necessary to cause the change to reach the centre of the crystals.

When this second type of deformation has penetrated to the crystal centres (and the strain at the crystal boundaries has not exceeded a certain value), the authors consider that the degree of axial alignment due to rotation has proceeded to such an extent that, on annealing, it is more easy for the atoms to form a single crystal than to revert to their original orientations.

With very large crystals, however, before the second type of deformation has penetrated to the centres, the strain set up at, and near, the crystal boundaries has become so great that, on annealing, it is more easy for the atoms in these highly-strained regions to form new crystals (*i.e.*, recrystallisation) than for a process of perfectly uniform and stable alignment to occur.

For equal amounts of tensile deformation, a surface crystal, not being subjected to interference with slip on all sides, is not affected to the same degree as an interior crystal, so far as the second type of movement is concerned. A greater degree of deformation is in consequence required before the change in surface crystals will be sufficiently complete to permit of growth or absorption during annealing. When, however, the critical degree of strain is caused by rolling, and the freedom of the surface crystals is thus at least partly removed, growth or absorption of the surface crystals can occur.

It has been frequently observed that, in large metallic crystals produced by annealing strained metals, small isolated crystals occasionally remain unabsorbed. This has been observed in aluminium by Carpenter and Elam, in tungsten by Jeffries, and in iron by the authors.

The authors consider that these crystals remain unabsorbed because they were larger than their neighbours in the original aggregate, and, having, therefore, a higher critical strain value they were insufficiently strained for absorption.

Note on Brittleness in Armco Iron.—Attempts were made to grow large crystals in Armco iron. Strips were cut from $\frac{1}{16}$-in. sheet, and to remove the last traces of carbon (0·02 per cent.) decarburisation was carried out in hydrogen, as in the case of the mild steel strips. On attempting to strain these decarburised strips extraordinary brittleness became manifest. Strips broke with no elongation, often under a load of only a few tons per square inch. So brittle were these strips that fracture would sometimes occur by merely dropping the specimens on the floor. This brittleness was not removed by heat treatment *in vacuo*, although gases were given off by the metal during this treatment. Experiments, which are being continued, show that this extreme brittleness is not common to all samples of Armco iron. In some cases pieces of decarburised Armco iron have shown a ductility and malleability at least equal to that of similarly-treated mild steel.

FIG. 20. NATURAL SIZE. CLEAVAGE FRAGMENTS OF IRON CRYSTALS.

FIG. 21. THREE-QUARTERS FULL SIZE. ELONG. 50%. MAX. STRESS 9·72 TONS.

FIG. 22. THREE-QUARTERS FULL SIZE. ELONG. 40·5%. MAX. STRESS 9·94 TONS.

(NOTE.—FIGS. 20 TO 22 HAVE BEEN REDUCED BY ONE-QUARTER.)

THE MACHINE TOOL TRADES' ASSOCIATION.—We have received a copy of a book entitled "British Machine Tools" which was recently prepared by the Machine Tool Trades' Association to give buyers, at home and abroad, information regarding the products of the individual firms who constitute the Association. It is a very fine production, giving many illustrations of the outstanding products of the works. In the cases of some machines specifications are given, while in others the capacities are clearly stated, and references are in all cases made to the outstanding features. The value of the publication, however, does not end there for a very comprehensive index is provided, by means of which the buyer can pick out immediately all the constituent firms who are makers of any specific type of machine. French and Spanish editions of this work are now in course of preparations, and the volume will be placed in the hands of some ten thousand machine tool users throughout the world.

SOUTH AFRICAN PETROLEUM.—The first meeting of Inyaminga Petroleum, Limited, was held in Johannesburg on February 26, says *The South African Mining and Engineering Journal*. In the course of his report, the Chairman, Mr. F. C. Dumat, stated that contracts had been entered into with Mr. Wm. Gallagher and the McNamara Shot Drills, Limited, for oil and coal boring respectively. With regard to boring for oil at Inyaminga, telegraphic advice had been received a few days before the meeting to the effect that the complete drilling plant had arrived at the boring site. It is estimated that at approximately 700-900 ft. oil may be located, although the company is prepared to go to 1,300 ft. before attempting a second hole, and ultimately to 3,000 ft. On the suggestion of the company's technical adviser, Mr. F. P. Mennell, Messrs. McNamara have commenced drilling at Villa Machado, with a view to testing the possibilities of coal measures. Mr. Mennell considers the coal measures are not very deep—at any rate, judging from surface indications. The selected boring site for oil is only 7-8 miles from Inyaminga Station. The company is working under pioneer conditions, and has had to build a road from the railway to the scene of operations. A drawback has been the lack of water, and it is thought that a borehole will have to be specially sunk to supply this need.